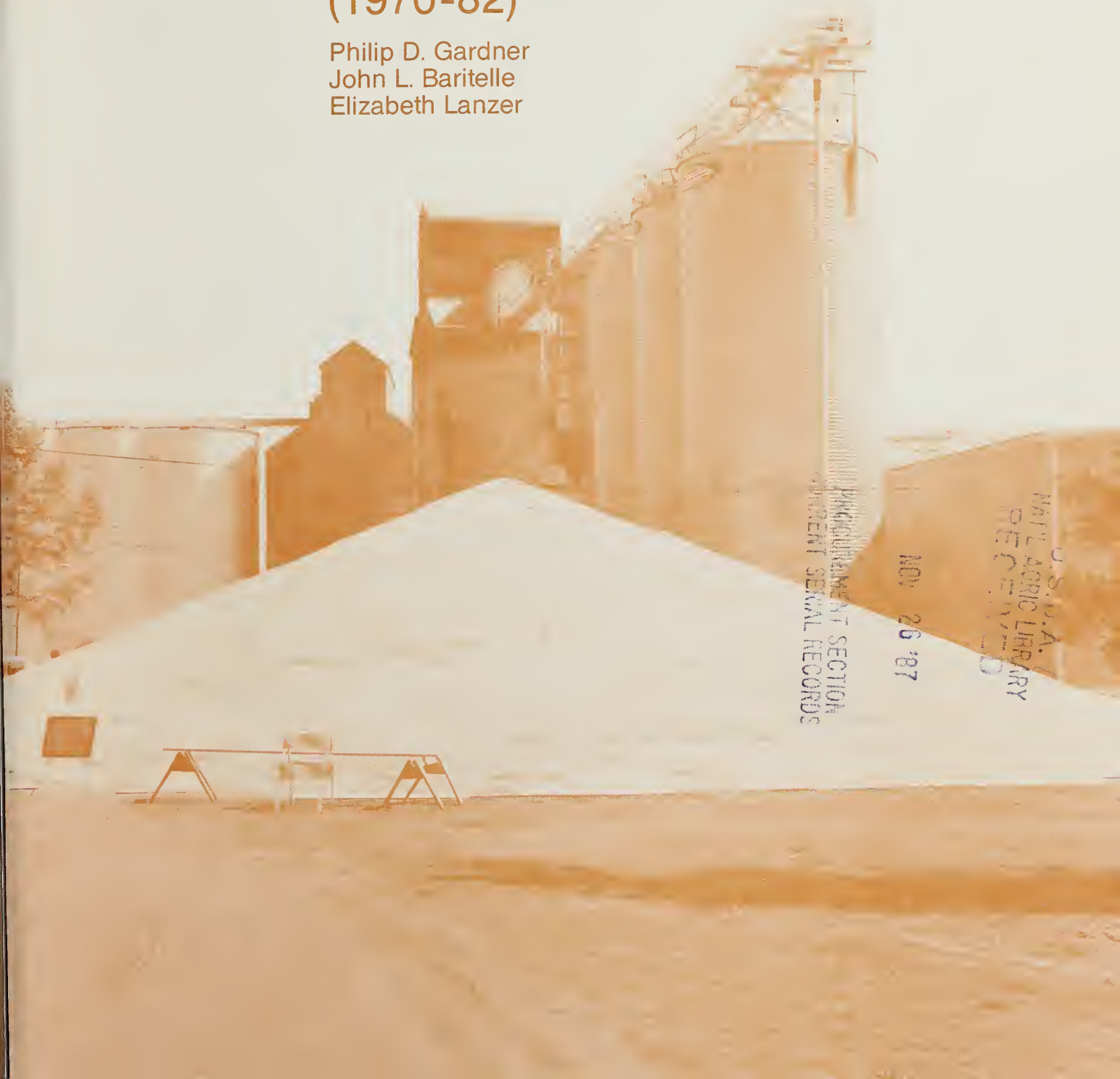
United States
Department of
Agriculture
Economic
Research
Service

Bibliographies
and Literature
of Agriculture
Number 56

Research on Economic Post-Harvest Loss

An Annotated Bibliography (1970-82)

Philip D. Gardner
John L. Baritelle
Elizabeth Lanzer



RESEARCH ON ECONOMIC POST-HARVEST LOSS: AN ANNOTATED BIBLIOGRAPHY (1970-82). By Philip D. Gardner, John L. Baritelle, and Elizabeth Lanzer, Resources and Technology Division, Economic Research Service, U.S. Department of Agriculture. Bibliographies and Literature of Agriculture No. 56.

ABSTRACT

This annotated bibliography of economic research publications (1970-82) on post-harvest loss focuses on economic analyses and data for appraising many types of food product losses. It expands on earlier studies, including perishable commodities as well as grains, and covers both developed and developing nations. It uses an economic framework, based on the concept of consumer surplus, to evaluate producer and societal losses associated with food losses. The bibliography contains annotated references on general literature plus those on grains, cereals, and pulses; rapeseed and spices; sugar; miscellaneous specific vegetables; general fruits and vegetables; apples; berries; tropical fruit produce; citrus fruits; and miscellaneous specific fruits.

Keywords: Economic post-harvest product loss, food and fiber losses, economic assessment, consumer surplus, producer surplus.

ACKNOWLEDGMENTS

This project was partially funded by the Graduate School of Management, University of California, Riverside (UCR), and the U.S. Department of Agriculture, Economic Research Service. The assistance of the Biological and Agricultural librarians at UCR is deeply appreciated.

SALES INFORMATION

Additional copies of this report can be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. Order by title and series number. Write to the above address for price information, or call the GPO order desk at (202)783-3238. You may also charge your purchase by telephone to your VISA, MasterCard, or GPO Deposit Account. Bulk discounts are available. Foreign customers, please add 25 percent extra for postage.

Microfiche copies ($6.50 each plus $3 for processing) can be purchased from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161. Order by title and series number. Enclose a check or money order payable to NTIS. Call NTIS at (703)487-4650 and charge your purchase to your VISA, MasterCard, American Express, or NTIS Deposit Account. NTIS will RUSH your order within 24 hours for an extra $10; call 800-336-4700.

The Economic Research Service has no copies for free mailing.

1301 New York Ave., NW
Washington, DC 20005-4788

October 1987

CONTENTS

Research on Economic Post-Harvest Loss

An Annotated Bibliography (1970-82)

Philip D. Gardner
John L. Baritelle
Elizabeth Lanzer

INTRODUCTION

Much of the food and fiber produced is lost to various disease pathogens, fungi, insects, rodents, and human mismanagement at the various stages of the food system. Pimentel and others (A37)[1] argue that perhaps half the world's agricultural production is lost before it reaches consumers. Additional food losses occur in homes as a result of poor handling, storage, and waste (Harrison and others, (A19)). Some of these economic losses are certainly avoidable. Reducing post-harvest losses to negligible levels, however, might cost more than the value of the quantity saved. As raw agricultural production is transformed through the process of storage, processing, transportation and distribution, marketing, and household preparation, economic value is added to the product. Polopolus (A38) estimates that the post-harvest value of food and fiber in terms of employment and other economic considerations is approximately twice that of production agriculture. Losses beyond the farm gate become increasingly costly in terms of other goods and services added to the raw agricultural product. Thus, food losses are costly, not only in terms of hungry people but also in terms of the efficient use of labor, capital, land, and other production inputs.

Literature on post-harvest losses is extensive; several useful bibliographies exist (Parkin (A34), Adams (B2), Mphuru (B41), Morris (A30)). Research has focused primarily on the loss of product in physical terms. Summaries of the literature (D. Singh (B52), Stokes (B57)) and conferences on post-harvest losses (Herzka (A20), Shuyler (A45)) acknowledge the paucity of economic analyses. The Food and Agriculture Organization of the United Nations (F4) has called for more involvement by economists in assessing post-harvest loss.

Economists have not become more involved for several reasons. First, measuring crop losses is partly an accounting problem. Many crops grown and processed worldwide have a multitude of potential final destinations and uses. The

---

Baritelle is with the Economic Research Service, U.S. Department of Agriculture stationed at the University of California, Riverside; Gardner was assistant professor, Department of Soils and Environmental Sciences, UCR, and is currently with Robert Hotaling and Associates, Haslett, MI; and Lanzer was a research assistant, Graduate School of Management, UCR.

[1]References are numbered in accordance with the system devised to classify the literature in the annotated bibliography part of this report.

physical loss for any crop is affected by the number of steps necessary to process it and by time lags at various stages in that process. A crop is sometimes exposed to several factors that cause extensive losses. Second, a crop or product can undergo quality changes caused by pest contamination, for example. Quality changes are difficult to account for in economic analysis because they may or may not be reflected in market prices. Third, crop losses include intangible costs that cannot be easily quantified, such as depriving rural people of their livelihood. A society's social institutions may be disrupted or even destroyed in the face of large crop losses. Although these costs cannot be easily measured, an economic assessment should acknowledge them, if they exist.

The major problem for economists is to find an economically workable definition for "loss." Appropriate questions are: What is the appropriate benchmark against which loss can be measured? How is physical loss translated into monetary terms for the individual and the firm? What value, if any, does society place on food losses? These questions have yet to receive serious attention, as this review will show. We offer a theoretical approach that will help researchers systematically and consistently address the physical loss of a crop and its economic implications.

This review of the post-harvest literature contains several references found in the most recent survey by Morris (A30) and identifies other studies since that 1978 publication. Our focus is on economic analyses and data available to appraise various types of food product losses. Unlike earlier surveys dealing with specific commodities or places (that is, grain crops or regions of the world, particularly developing nations), our study includes perishable commodities and expands coverage to the United States and Europe. The content of the annotation is limited to describing recent assessments of post-harvest loss, procedures used in making economic evaluations, and the data sources used in these evaluations.

ECONOMIC ASSESSMENT OF POST-HARVEST LOSSES

Why be concerned with economic assessments of crop loss? First, managers cannot make decisions at the micro or firm level without information. The farmer, packinghouse manager, grain elevator operator, food processor, and supermarket manager all need information on the economic implications of losses. This information helps decisionmakers weigh alternative management strategies. By increasing the economic efficiency of available resources, the firm can realize a higher profit.

Second, crop loss information can be used to establish a national agricultural policy agenda at the macro level. Food loss reductions have crucial implications for national policy regarding land use, soil erosion, agricultural trade, and public service programs. National policymakers now know little about the relationship between post-harvest losses and other agricultural policy issues.

Definitions

The first question in analyzing food losses in monetary terms is: What is being measured? One can describe losses in several ways: (1) strictly in terms of weight or production loss, (2) in terms of changes in product quality, and (3) in terms of risks to public health (Howe (A23)). The magnitude of the loss can be given in absolute terms or can reflect socially acceptable standards for loss levels.

Post-harvest production or weight losses occur primarily during storage and transportation and can be caused by insects, rodents, or other pests. Accurate measurement of weight loss can be hampered by water absorption or by the additional weight of live and dead insects. The latter situation can be corrected somewhat by higher quality standards for stored products. Such standards may apply more to developed nations than to less developed ones.

Deterioration of the quality of food and fiber products can be caused by decay, pest contamination, or physical changes in the product. If any part of the produce has been eaten, the entire product may be rejected. For example, 3 or 4 percent of the fruit decayed in a box of citrus can cause the entire box to be discarded (Bancroft and others (K1)). Quality changes are often accelerated by pests and poor management during handling and storage.

Although an elusive concept, public health risk may also be considered a form of loss. For example, insects such as cockroaches can carry diseases that can be transmitted to humans. The chemicals used to control pests sometimes present an even more serious health risk. Improper handling of chemical fumigants and insecticides can jeopardize not only workers but consumers who are exposed to chemical residues. Many countries have limited the types and amounts of chemicals that can be used. Some countries will not import produce treated with restricted chemicals.

We focus here on production losses implied by a change in product quality. Although gross monetary estimates can be made on the value of the product lost at the firm level, several factors may hamper a thorough economic analysis. First, weight and quality losses may not be noted or measured. Second, few countries have set specific standards against which weight and quality losses can be valued. Japan, the United States, and the European Common Market countries tend to have high quality standards for what is permissible for human food. Other countries may have little idea what standards should be set, if they recognize a need at all. Third, economic evaluations have not been included in the design of post-harvest management strategies for controlling chemicals in food processing. In an economic study conducted by Bancroft and his colleagues (K1), minor changes in packinghouse arrangements were shown to reduce the decay of lemons arriving at market, to keep chemicals used for pest control within acceptable standards, and to be economically feasible. Finally, these definitions tend to focus on the valuation of specific aspects of the food production system, specifically the handling of the product through the transformation process. The indirect effects of food losses and the unexpected consequences of preventing food losses are ignored or not accounted for. For example, improving grain storage facilities in a developing country may make more grain available for marketing. Increased supplies may reduce prices, however, causing hardships for individual farmers who cannot afford to receive lower prices.

These definitions of loss may be imprecise, thus making monetary valuations more difficult. Furthermore, confusion over what constitutes a loss makes it difficult to develop a conceptual framework from which economists can examine losses.

Conceptual Framework for Economic Evaluation

Most production processes can be defined in the following manner:

$$Y^* = g(X_1, X_2, \ldots, X_k)$$

where:

Y^* = yield output with a given pest or disease level i;
X_1 = variable input (for example, water fungicide, labor, and capital); and
$X_2,..,X_k$ = other inputs held at fixed levels.

The specific functional and mathematical form of the technical relationship depends on the particular transformation process described. Figure 1 shows three different functions, each with varying levels of X_1. Relationship Y^1 traces the transformation of X_1 under nearly ideal conditions, usually attainable only in a controlled laboratory environment. The theoretical maximum of production is at point A. One might be tempted to use this point as a reference or benchmark to measure total loss. However, production at point A is very difficult to obtain under actual operating conditions at the processing plant or the farm.

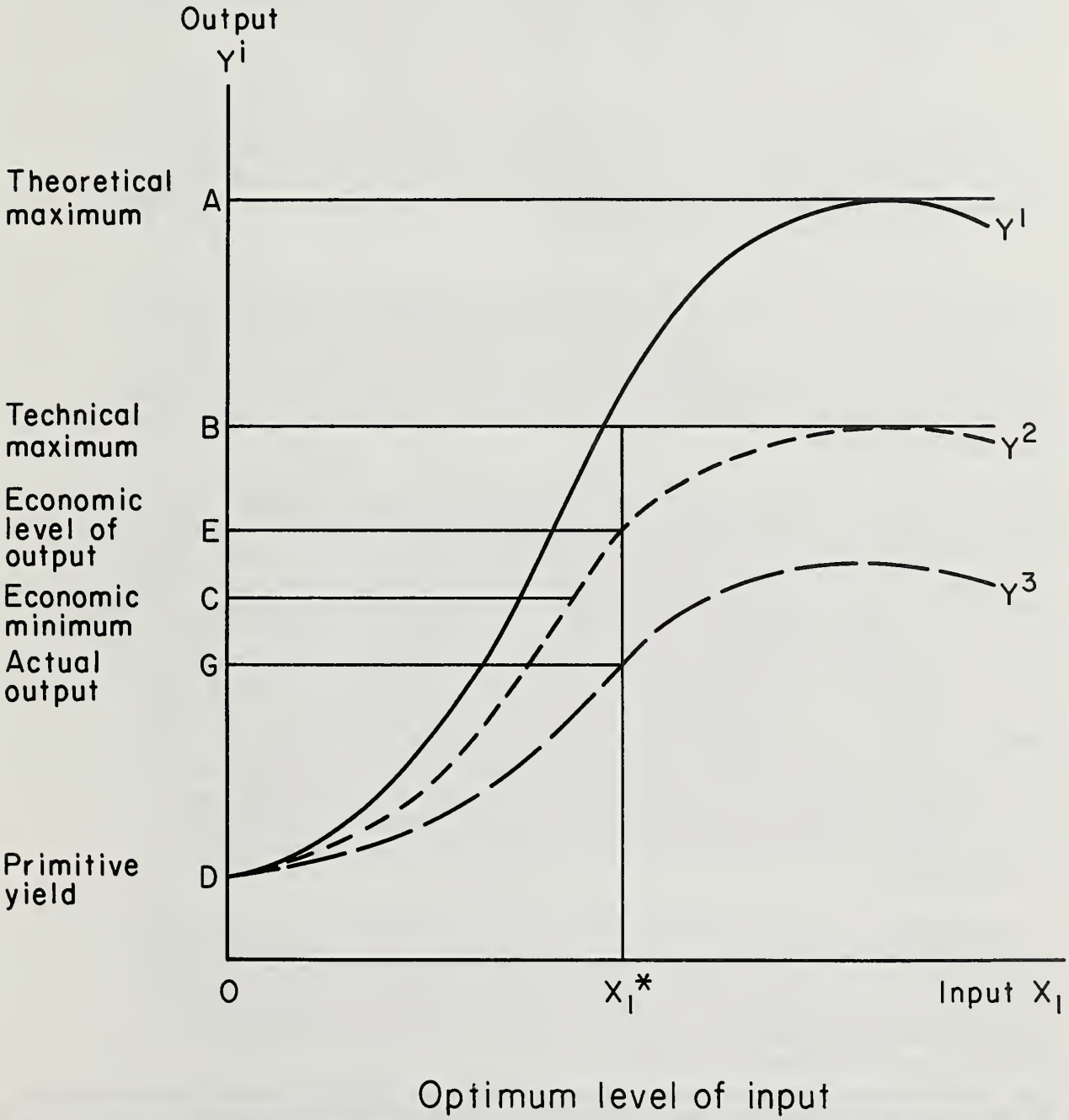
At the other end of the production process is primitive yield, that output occurring when none of the variable input X_1 is applied (point D on fig. 1). Even without the variable input, some level of output can usually be obtained. Of course, this is not always the case, and a zero level of input may imply a zero level of output. Then, the curve depicted in figure 1 would go through the origin.

An infinite number of possible configurations represent input-output relationships between D and A in figure 1. For example, Y^2 represents something we might call attainable yield; that is, yield obtained with good management practices under normal field conditions. Point B corresponds to the output that is a technical maximum under those conditions. Any point within Y^2 represents a lack of good management practices and an inefficient use or combination of resources. In other words, if production is at a level not on the curve Y^2 but is at some point within its interior, either more production is possible for that level of resource or less resource is required for the same level of production. Thus, a technical inefficiency occurs with respect to the required inputs, including management practices.

What about economic efficiency? Once managers commit their inputs to the production process, these inputs are irretrievably lost; they cannot be reclaimed. Because inputs are costly, managers try to derive maximum economic benefits from these resources. Misallocation of resources results from natural catastrophes, lack of management ability, lack of knowledge, or ignorance. What criterion then do managers use to determine the optimum level of X_1? They maximize their profits. Rational economic behavior dictates that output is something less than the technical maximum; it does not pay to apply additional levels of input X_1 which yield lower levels of output. Unless input X_1 is a free good with no price, economic levels of output will be lower than the level that is technically possible (B). In fact, given the technical relationship between Y^2 and X_1, the more costly the input X_1, the less it is used. However, on the curve between D and C, for every additional unit of X_1, there is an increasing output response. If it pays to undertake the production process at all, output should be at least at point C, the economic minimum or the point of inflection. As successive inputs of X_1 are added, the law of diminishing returns takes effect where, for each additional unit of X_1, the rate of increase in output actually decreases.

Thus, profits will be maximized somewhere between points C and B. The precise point will depend on the cost of the input X_1 and the price of the output Y, given the technical relationship expressed by Y^2. That point will be the place where the additional cost of a unit of input is equal to the value of the additional production it generates, or the marginal revenue (MR) equals the marginal cost (MC). As long as the cost of an additional unit of input is less than the increment

Figure 1: Production Function Describing the Transformation of X_1 into Output Y under Different Assumptions



of revenue it yields (output), it pays to add more input because profits are increased. Therefore, given a unit cost for X_1 and a price for Y, a point such as E in figure 1 represents both economic and technical efficiency.

The question of physical crop loss for the individual firm can now be logically approached from the economist's viewpoint. Assume the firm is technically efficient operating on curve Y^2 and has economically committed X^*_1 level of inputs. Should a new pest problem be introduced, production at all levels will be reduced. This situation is reflected in the curve Y^3. Physical loss attributed to the problem is then E, the benchmark, minus G (E-G), provided inputs are not adjusted. Profits for the individual firm are reduced accordingly. Aggregate losses can be summed across all firms experiencing a similar problem.

Losses at the individual firm level do not ordinarily change prices noticeably. Exceptions occur where one firm has a significant portion of the total supply and the demand for the product is fairly sensitive to price. There are generally enough firms in the agricultural sector that market price is unaffected by the losses a single firm incurs. One can measure the value of such a loss by multiplying the market price times the quantity lost.

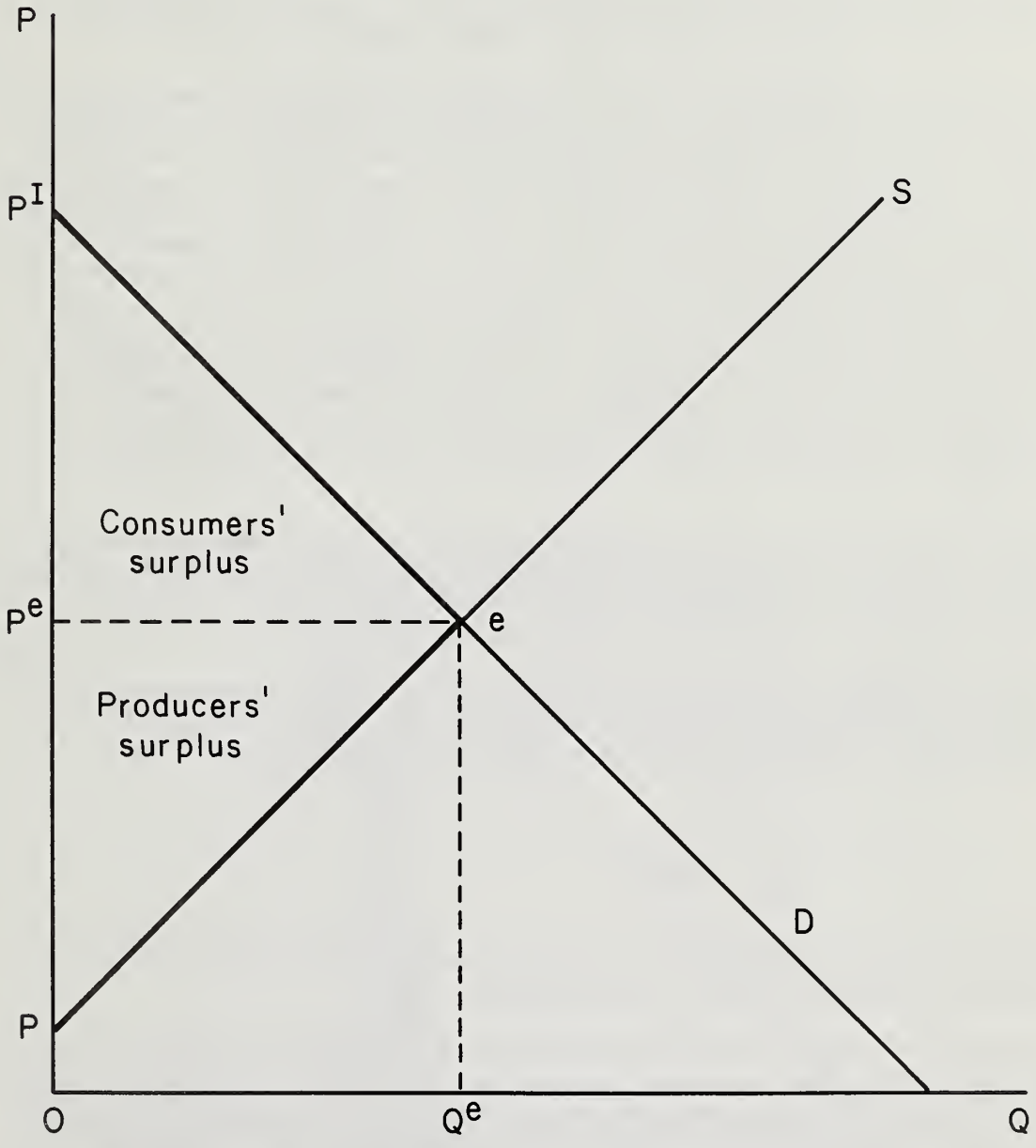
The problem of loss becomes more complex when a significant portion of an industry's supply is affected. The value of the loss, measured in terms of market price, increases as supplies are curtailed. The impact of actual physical losses to an industry tends to be mitigated as price rises. In fact, price can rise by a greater percentage than quantities to be sold are reduced. In such cases, revenues to an industry can be actually increased. How then is the value of an industry-wide loss evaluated?

When an industry suffers a sudden, unforeseen, and significant product loss, market prices are affected and losses need to be assessed across the whole of society. One can do so by using the notions of consumers' and producers' surplus. Figure 2 represents the traditional supply and demand relationships for an agricultural commodity. Line D represents the demand relationship where consumers are willing to pay for various amounts of product. As price decreases, purchases increase. Line S represents the industry supply relationship where producers are willing to supply the product at various prices. As prices increase, producers are willing to increase supplies. At equilibrium, then, the price consumers pay and the price producers receive is the same. The equilibrium price is represented by P^e (fig. 2). Some consumers may be willing to pay more than P^e, but they need not as a result of a single market price. Some producers or processors may also be willing to accept less than the price established in the market. Benefits accrue to both consumers and producers, designated as the consumers' surplus and producers' surplus (fig. 2).

To measure the consumers' surplus, note that each additional unit sold lowers the price paid by consumers. The sum of each additional unit sold times its respective price above P^e represents the surplus generated to consumers as a result of having a single market price. In this example, area P^eP^Ie represents the benefits accruing to consumers. This area is defined below the demand curve and above the equilibrium price line, P^ee.

To measure the producers' surplus, note that suppliers are willing to supply additional units as price increases. A competitive industry will supply its product so long as it recovers its operational (variable) cost and perhaps some of its overhead (fixed) costs. Thus, the price at which each additional unit is sold, according to supply curve S, represents the industry's operational cost for that

Figure 2 : Consumers' and Producers' Surplus



unit. The sum of each unit times its respective price up to P^e represents the cost to the industry to produce Q^e. Hence, total operational costs to the industry are represented by the area OP^eeQ^e. Total revenue received by the industry is price P^e times the quantity sold Q^e. This amount is represented by the area OP^eeQ^e. Total revenue minus total cost defines total producers' surplus, or profit plus returns to fixed assets. This amount is defined by the area contained in P^eeP or by the area above the supply curve and below P^ee. Producers willing to supply the product at prices below P^e benefit by receiving a single market price P^ee.

Total societal benefit as a result of the market price is the sum of the producers' and consumers' surpluses. This amount is represented by the area P^IeP.

The concept of consumers' and producers' surpluses provides the framework to logically evaluate the question of loss. We shall briefly address several scenarios. Assume that a sudden, unforeseen catastrophe reduces production to level Q^* in figure 3. This amount is equivalent to a vertical supply curve S^*. Nothing can be done to mitigate the damage. Operational costs remain the same. Available supply is reduced by (Q^e-Q^*), and prices increase to P^* from P^e or by an amount P^*-P^e. Consumers' surplus is reduced by the area defined as $P^eP^*e^*e$. Producers now receive revenues equal to P^*Q^* as represented by area $P^*e^*Q^*$. Thus, there is a transfer from consumers to producers defined by area $P^eP^*e^*f$. Area fe^*e is not transferred and represents the net loss to society. Because of the unexpected nature of the loss, costs do not change; only revenues change. Producers gain area P^eP^*ef, but lose area Q^*feQ^e. The total loss to society as measured by consumers' and producers' surplus is defined by the area fe^*e plus Q^*feQ^e or $Q^*e^*eQ^e$.

This area, $Q^*e^*eQ^e$, can easily be approximated if one knows the normal or expected production and its corresponding expected price. By taking the estimated loss, Q^*-Q^e, and by multiplying it times the average of P^e and P^*, $1/2\ (P^e+P^*)$, one can estimate the value of the loss to society.

Even if the demand relationship is not linear, one can approximate such a loss using this simple concept. When the demand relationship is nonlinear and the physical loss is fairly great, one can make a more precise statement from:

$$\int_{Q^*}^{Q^e} D(t)dt$$

Should the industry take steps to control the problem after it has occurred, one can add the cost of control to the foregoing loss figure.

A somewhat different question concerns the cost to society of an existing pest problem. In this case, we assume the problem is anticipated whereby inputs such as pesticides, fungicides, fumigants, and cold storage can be adjusted accordingly. In other words, costs change because input levels change. Total production will also change. Figure 4 shows the supply and demand relationships with and without the specific problem. S^I represents the industry shift in supply as a result of the problem. Unlike the previous case where losses were not anticipated and input adjustments were not made, changes in input levels are reflected in different costs of production. In the absence of the problem, operational costs are described by area $OPeQ^e$. When adjustments have been made for the pest, costs are now described by area OIe^IQ^*. The reduction in consumers' surplus under the two different circumstances is equal to the area of triangle P^IeP^e minus the area of

Figure 3 : Consumers' and Producers' Surplus Measuring Total Societal Loss from a Sudden Unanticipated Catastrophe

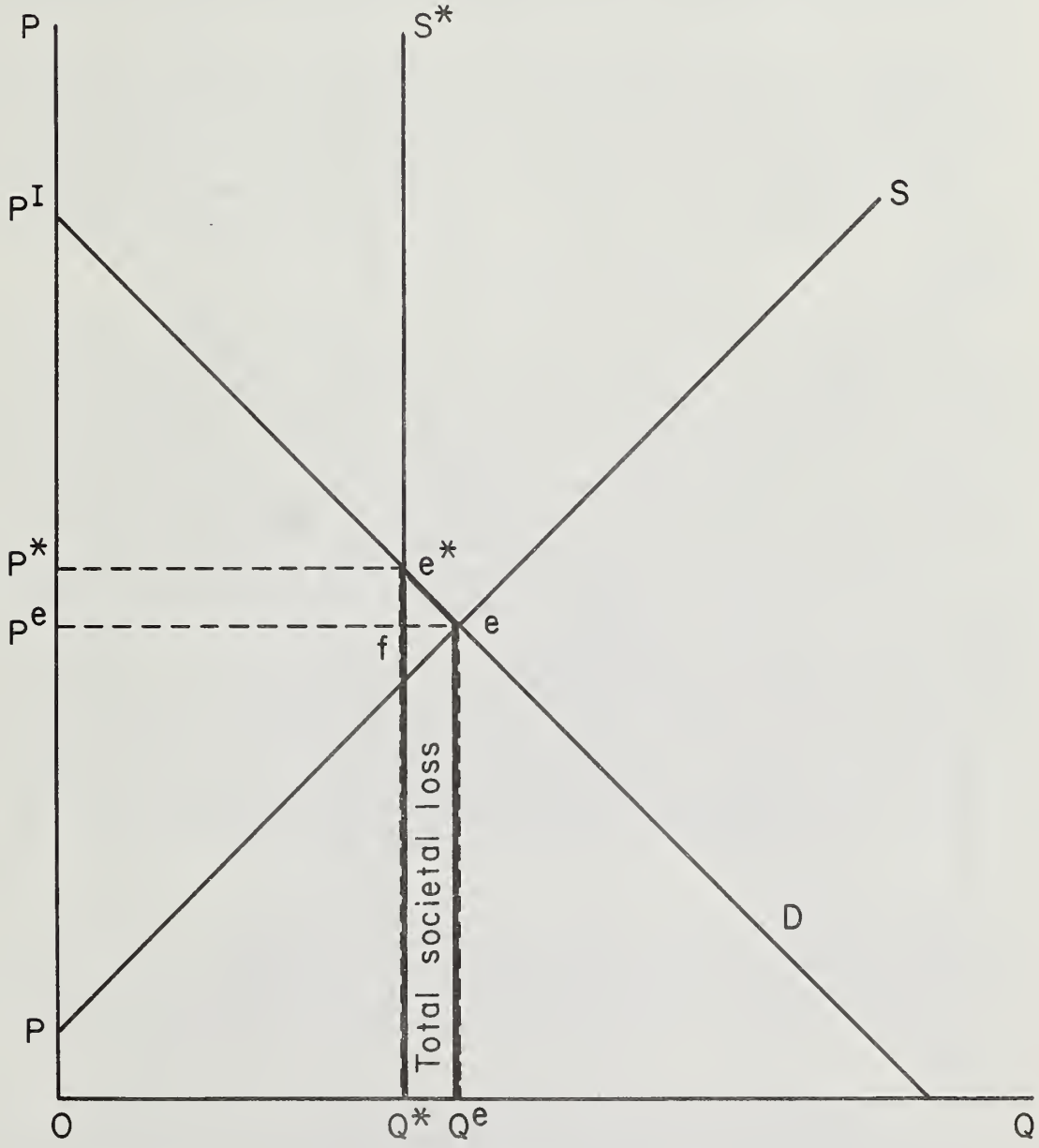
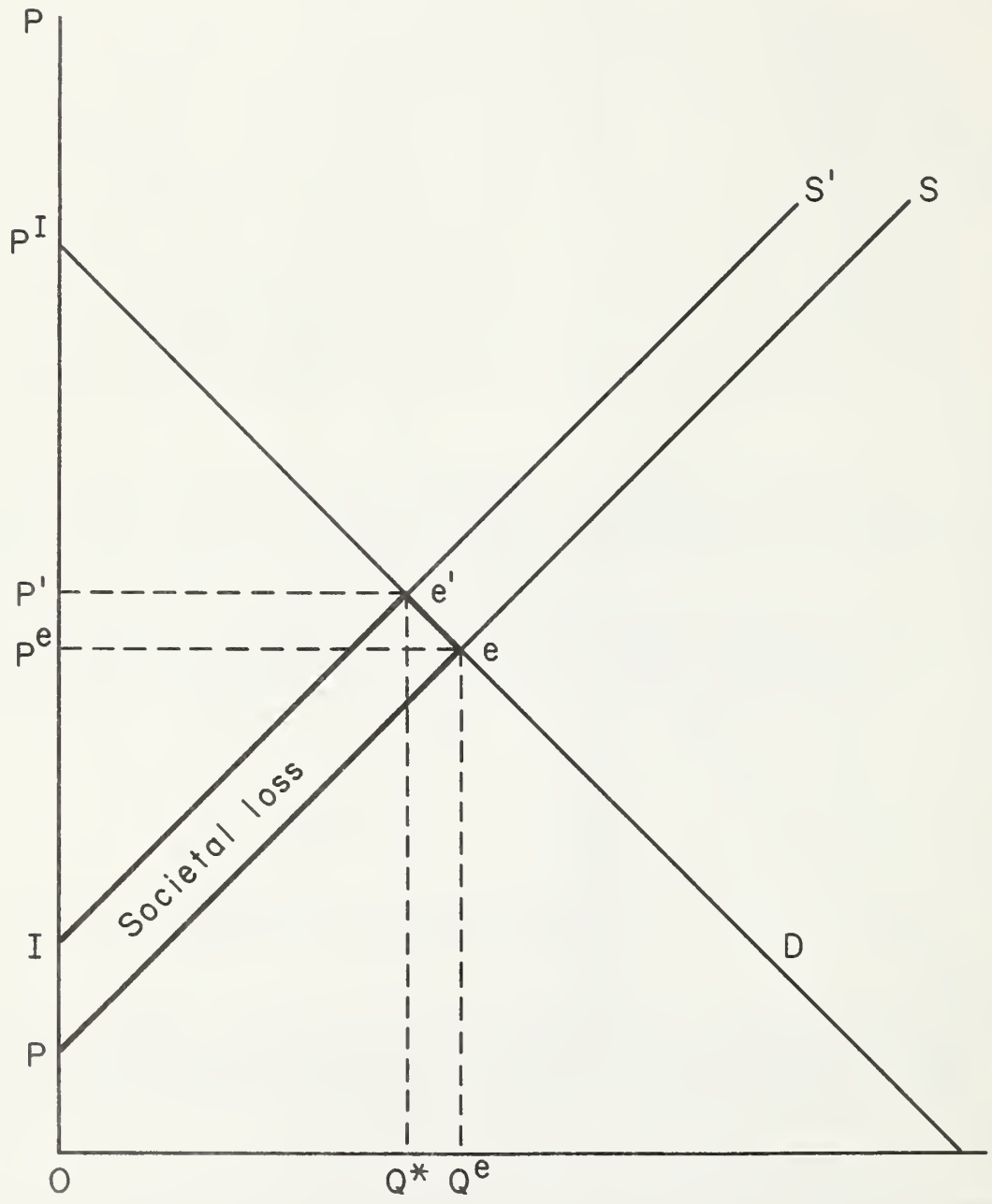


Figure 4: Consumers' and Producers' Surplus Measuring Societal Loss from an Anticipated Problem



triangle $P^{I}e^{I}P^{I}$. The reduction in producers' surplus is equal to area $P^{e}eQ^{e}$ minus area $P^{I}e^{I}Q^{*}$. The total societal loss is defined as the area $Ie^{I}eP$. Mathematically this area is equal to:

$$\left[\int_{0}^{Q^{e}} D(t)dt - \int_{0}^{Q^{e}} S(t)dt\right] - \left[\int_{0}^{Q^{I}} D(t)dt - \int_{0}^{Q^{*}} S^{I}(t)dt\right]$$

One can evaluate a new technology that may reduce an existing pest problem using this rationale. One can also compare several alternative technologies as to their overall value to society.

Within this general economic framework of consumers' and producers' surplus, we can discuss the implications of reducing the supply of food and fiber. However, we cannot adequately address questions of public health, reduced employment, and other social problems that may result from serious post-harvest losses because of the difficulty of measuring their costs. Nevertheless, a post-harvest loss assessment may need to account for these impacts, if only by describing them.

Information Requirements

Table 1 shows the information required in an economic post-harvest loss assessment. Loss assessment at the individual firm level requires a knowledge of the expected economic level of output; that is, what would production have been in the absence of the particular problem? The difference between the expected economic level of output and the actual output represents the physical loss. One can translate this figure into monetary terms by multiplying it times the market price. Any additional handling or processing costs encountered by the firm should be added to its lost revenues. When losses are sustained by a number of firms or if a significant portion of an industry's supply is affected, an industry-wide assessment should take changes in the market price into account.

To account for the impact to society when individual firm losses are summed across all firms, one should employ the theory of consumers' and producers' surplus. In the case of a sudden, unexpected loss, one needs to know only what the expected industry production and the corresponding expected price would have been. By comparing actual production with expected production yields, one can measure the loss in physical terms. The physical loss times the average of the actual price and the expected price yields the monetary loss to society of the loss in food.

To assess the cost to society of an existing pest problem or to evaluate the value to society of a technology, one needs a mathematical statement of the industry's supply and demand relationships. The economics literature contains a number of these relationships; however, one may have to estimate such relationships from market and production data.

Placing a value on indirect costs is more difficult. We have no systematic procedure for addressing and evaluating the cost to society of those indirect cost items listed in table 1. Nonetheless, a loss assessment should at least describe these indirect costs.

SOURCES FOR BIBLIOGRAPHY

The Bibliography of Agriculture was the primary reference source in the compilation of this bibliography. We examined the 1970-82 period for appropriate citations under the subject headings post-harvest, harvest, and storage. The University of California's (UC) computerized catalog of materials available at UC libraries and the card catalogs of the Riverside campus' Biological and Agricultural Sciences Library, the University of California's Natural Resources Library at Berkeley, and the Giannini Foundation Library served as supplemental sources.

We then made a computerized search of the AGRICOLA bibliographic data base from the National Agricultural Library to identify any citations that had been overlooked. Reference lists from selected articles helped us identify important earlier works (prior to 1970) in the field and additional citations not located in the primary and supplemental sources. Post-harvest Food Losses in Developing Countries: A Bibliography by the National Academy of Sciences in 1978 (A30) and Losses Which Occur During Harvest and Storage of Grains: A Bibliography by A. N. Mphuru in 1976 (B41) contained helpful references. We also included several citations suggested by colleagues and several references from 1983 and 1984 that became available during the study period.

We used several additional criteria, besides the post-1970 period, to decide whether to include an article in the bibliography. First, the literature had to address the issue of post-harvest food or fiber loss in a manner relevant to measuring substantive or qualitative changes in a product. We focused on the existence of quantified measurements of physical change that could be converted into economic

Table 1--Information required to conduct an economic analysis of post-harvest food and fiber loss

1.	Individual firm level
	a. Economic level of output
	b. Reduced quantity and/or quality
	c. Increased handling costs
	d. Increased processing costs
2.	Societal level direct costs
	a. Supply and demand relationships
	b. Aggregate loss
	c. Aggregate increased handling costs
	d. Aggregate increased processing costs
3.	Societal level indirect costs
	a. Reduced employment
	b. Reduced community income
	c. Reduced markets
	d. Environmental problems
	e. Public health
	f. Social unrest
	g. Government stability

terms rather than on discussions of specific loss reduction techniques that often fail to identify the amount of physical product they affect.

Second, the article had to be easily accessible and to have been written in English or to have provided an English summary. We made exceptions for foreign language articles extensively cited in leading English-language articles. A number of foreign articles, especially those from Soviet and East European journals, were difficult to obtain, and few appear in this bibliography.

We examined the selected articles for three specific features: (1) physical measurement of loss, (2) quantification of loss in monetary terms, and (3) type of methodology for economic loss assessment employed. Each annotation attempts to capture the general flavor of the article, indicating whether the article reports results from field or laboratory experiments, is part of a post-harvest conference proceeding, or reviews post-harvest loss assessment.

We describe the loss data presented in each article and note any economic analyses or evaluations. The annotations also indicate whether the article cites references.

SUMMARY OF THE LITERATURE

We organized the bibliography into 11 major groups to accommodate the wide range of commodities discussed in the literature (table 2). The general category contains references that have a major post-harvest loss theme, but are not crop specific. Conference proceedings and review articles are often included in this category. More specific commodity groups, for example, are listed if only one or two references specific to that commodity were identified and located. Grain crops, where specific grain commodities are not separated, and general fruits and vegetables, where several commodities are discussed in a single article, are exceptions to this rule. Our decision tends to emphasize perishable commodities. Each commodity group is given an alphabetical code (A to K) for easier location in the annotated section. Appendix B provides a primary author index.

Table 2 shows the number of references in each major category. Scientists have paid more attention to grains and citrus fruits than to other commodity groups, with grains having the most citations. However, when the general crop category is excluded, perishable crops taken together contain nearly twice as many citations as do grains and other commodities.

Based on the information extracted from each article or book annotated, we have cross-indexed each reference based on five major characteristics: type of literature, cause of loss, phase of loss, loss data provided, and geographic region. Each characteristic is further broken into subcategories. For example, type of literature is separated into general discussion, field studies, and laboratory experiments. The major problem with these subcategories is that they are not always mutually exclusive. Each characteristic and its subcategories reflect an issue commonly raised by scientists and analysts studying post-harvest losses.

The type of literature index (table 3) classifies references as general discussions, collections of papers, field studies, and laboratory experiments. Bibliographies are listed as general discussions. Most articles and books on post-harvest losses are general articles. Laboratory results constitute the major portion of the remaining articles and pertain primarily to perishable commodities. Field studies are commonly conducted with grain crops or less perishable commodities.

Table 2--Major commodity groups and codes used in annotation

Crop code	Categories	References	Proportion of total
		Number	Percent
A	General	52	21
B	Grains, cereals, and pulses	60	26
C	Rapeseed and spices	3	1
D	Sugar	2	1
E	Specific vegetables: Miscellaneous	25	11
F	Fruits and vegetables: General	20	8
G	Apples	8	4
H	Berries	5	2
I	Specific fruits: Miscellaneous	15	6
J	Tropical fruit produce	10	4
K	Citrus fruits	38	16
	Total	238	100

Losses of food and fiber can be attributed to disorders (rots, diseases, and viral or bacterial pathogens), insects and rodents, internal chemical actions, handling, and other causes. Internal chemical action pertains to the natural maturing of a product given particular conditions. Other causes include factors such as poor household use of food resources. Most references concern disorders and internal chemical actions; both perishable and nonperishable commodities are well represented. Studies on insect and rodent losses have been confined to grains and other nonperishable crops. Handling of particular perishable commodities is an important source of loss. Table 4 indexes the cause of loss.

Losses occur throughout the post-harvest food system. Table 5 indexes the references according to the stage at which the loss takes place. It includes neither references to information on losses occurring at all stages nor post-harvest losses in general. Onfarm losses pertain to those studies focusing on losses between harvesting and storage. Household losses take place after the consumer has purchased food items. Economists often neglect this final stage of the food system when estimating food losses. The preponderance of studies has been on storage losses, particularly on grains in less developed countries. Much less attention has been given to processing, transportation, marketing, and household losses.

Table 6 identifies the type of loss information included in each study. Those studies listed under weight (amount) or percentage loss categories generally provide scientifically estimated data. Data in these two categories are peculiar to a specific set of conditions. For example, the percentage of decay in a box of fruit subject to storage is given for a specific period under specified temperature and atmospheric conditions. Some percentage losses, however, are little more than guesses on national losses of particular commodities. Table 6 shows that most studies provide weight/amount and percentage losses for all commodities. References including measurements of post-harvest quality losses, such as nutritional value losses, are listed separately.

Researchers have worked primarily on quality losses for perishable commodities. We identify and index separately those studies providing economic evaluations of any type. Although no data are provided in the loss assessment methodology category, articles under this heading do indicate how loss assessment data are generated. We review and discuss literature listed in these last two categories (economic evaluations and assessment methods) more fully in the next section.

The final characteristic concerns the geographic region in which the study was conducted. Two general subcategories, developed and developing nations, and specific continental regions compose the seven geographical regions used in this index (table 7). If the citation contains no information pertinent to a particular region, the article is not listed in this index. Table 7 focuses on the region of the loss, not on the source of the citation. Several examples may help explain the indexing procedures. This index would not include an article from a Japanese journal reporting laboratory results on how fast a specific insect would consume rice because of the wide application of the results. An article on post-harvest fruit research pertinent to India would be included in the subcategory India. Because of the language criterion used in selecting articles, there is a heavy emphasis on U.S. studies. Many foreign reports are often not published in journals and can be identified only through other sources. Additional studies on post-harvest losses may exist in countries where government and university technical reports are not widely distributed. When the India, Africa, and Asia subgroups are added to the developing nations, one can see that researchers have worked extensively in these countries, principally in the areas of grain and subsistence crops.

Table 3--Annotations, by type of literature

General discussions: A2, A4, A6-A9, A11, A13, A17 A21-A28, A31-36, A38, A42, A43, A45, A50-54, B2, B6, B8, B11, B18, B20, B27, B28, B31, B33, B34, B36, B37, B39, B41, B47, B49, B50, B52, B58, B59, D1, E3, E6, E7, E9, E12, E13, E19, E21, E22, E25, F3-F6, F8, F10, F14, F15, I1, I12-I14, J1, J4, J7, J10, K5, K6, K8-K10, K16, K17, K31, K32, K37

Collections of papers: A5, A20, A37, A46, A55, B9, B16, B51, B57, F1, F13, J5

Field study: A1, A3, A10, A12, A15, A18, A19, A29, A33, A39-A41, A46, A48, A49, B1, B3, B5, B13, B14, B15, B17, B19, B21-B26, B30, B32, B34, B35, B53, B55, B56, B60, C1, C2, E2, E8, E14, E16, E18, E24, F2, F17, F18, I3, I4, I6, I9, J2, J6, K1, K13

Laboratory study: A14, A16, B7, B10, B12, B29, B40, C3, D2, E1, E4, E5, E10, E15, E17, E20, E23, F7, F9, F11, F16, F19, F20, G1-G8, H1-H5, I2, I5, I7, I8, I10, I11, J3, J8, J9, K2-K4, K7, K11, K12, K14, K15, K18-K30, K33-K36, K38

Table 4--Annotations, by cause of loss

Disorders: A37, A52, A54, B3, B21, B41, B51, B59, B60, D2, E5, E12, E17, E25, F1, F7, F16, G1-G8, H1-H5, I2, I4, I5, I8, I10-I12, I14, J2, J4, J7, J8, K4, K6, K8-K11, K13, K15-K19, K22-K25, K27-K29, K31, K33-K35, K38

Insects/rodents: A10, A11, A13, A16, A17, A22, A36, A47, A48, A52, B1, B9-B12, B14, B15, B17, B20-B27, B32-B35, B38, B41, B42, B48, B52, B54, B58, B59, C1, C3, F2, F17

Internal chemical actions: A14, A37, B3, B11, B22, B23, B29, B43, B53, B55, B56, C2, D2, E4, E10, E17-E20, E23, F1, F3, F6-F9, F11, H5, I1, I7, I13, J2, J5, J9, K2, K3, K5, K7, K14, K20, K21, K32, K36, K38

Handling: A22, A27, A28, B18, B20, B21, B26, B41, B44, B48, E1, E14, F4, F5, F8, F11, F12, F15, F16, I3, I4, I9, J2, J6, J10, K1, K5, K8, K9, K12-K14, K17, K22

Other: A1, A4, A7, A15, A18, A19, A31, A34, A39, A40, A41, A49, A50, B20, B53, D1, E22, F14

Table 5--Annotations, by phase in the post-harvest food system

Onfarm: B14, B30, B55, B56, G8, J6, K27

Storage: A2, A5, A6, A10, A11, A14, A16, A21, A24, A28, A42, A48, A50, A53, A54, B1, B3, B4, B7, B9-B17, B19, B20, B22-B27, B29, B30, B58-B60, C1-C3, D1, E3-E7, E9-E12, E15-E21, E23-E25, F1-F3, F5-F9, F15-F17, F19, F20, G1-G8, H2-H4, I1, I2, I5, I7, I10, I11, I13, I14, J1-J3, J5, J7-J10, K2-K4, K6-K9, K14, K17-K26, K28-K33, K36-K38

Processing: A7, A22, A27, A44, A50, B9, B18, B31, B36, B38, B40, B50, E1, E4, E14, E22, F8, F10, F11, F14, F16, I3, I4, I9, J6, J10, K8, K14, K17, K20

Transportation: A2, A48, A50, B9, B38, B47, B52, E1, E2, E14, F2, F5, F6, F8, F11, F15, J1-J3, J10, K5, K14, K35

Marketing: A3, A4, A48, A49, A50, B24, B44, B52, E4, E14, E19, F1, F5, F10, F18, G4, I6, J2, J5, J10, K2

Household: A1, A15, A18, A19, A27, A39, A40, A41, A50, B3, F18

Table 6--Annotations, by type of loss data reported

Weight or amount figures: A2, A4, A6, A7, A18, A24, A37, A43, A48, A49, A50, A52, B1, B3, B7, B13, B14, B17, B19, B20, B22, B25, B31, B37, B38, B40, B42, B43, B47, B48, B50-B53, B55-B59, C3, E4, E5, E10, E15, E18, E20, E22, E24, E25, F1, F3, F6, F7, F9, F11, F12, F15, F17, G4, H4, I1, J5, K3, K7, K14, K20, K21, K36

Percentage loss figures: A1, A4-A6, A8, A9, A15-A17, A19-A22, A28, A29, A36-A39, A41-A43, A47, A52, A53, B5, B7, B8, B10, B11, B12, B13, B15, B16, B19, B20, B22-B26, B32, B33, B36-B40, B42, B45, B50-B52, B54-B57, E1-E3, E5, E7, E8, E14-E17, E19, E21-E23, E25, F1, F2, F4, F7, F10-F13, F16, F19, G1-G8, H1-H3, H5, I2-I6, I8, I10, J2-J8, K3-K8, K10, K12, K15, K16, K18, K19, K22-K27, K29, K30, K32-K36, K38

Quality terms: A29, A33, A44, B3, B6, B8, B9, B11, B18, B20, B24, B25, B30, B46, B52, B60, C2, C3, D1, E4, E20, E24, F9, F13, F14, G7, H1, I4, I5, I7-I9, I13, J6, J9, K2, K4, K5, K20, K32

Economic values or figures: A2, A4, A5, A7-A10, A11, A13, A15, A17, A19, A20, A25-A27, A29, A31-A33, A35-A37, A39-A41, A46-A48, A50, A51, A55, B1, B3, B16, B17, B19, B22, B26, B29, B30, B42, B47, B52, B55, B60, D2, E11, E12, E22, E24, E25, F2, F4, F12, F17, G5, J2, J7, K1, K16

Loss assessment methodology: A45, B4, B28, E9

Table 7--Annotations, by geographic region

Developing nations: A1, A5, A11, A13, A46, A55, B6, B8, B41, B57, D1, F1, F4, I2

Less developed nations: A9, A13, A16, A17, A20, A25, A28-A31, A42, A44, A51, A53, B2, B6, B22, B33, B41, B57, B59, E4, E8, E9, E18, F3, F4, J6, J10, K12

United States: A1, A2-A4, A11, A15, A18, A19, A26, A32, A36, A39-A41, A47, A49, A50, A52, B10, B18, B22, B29, B30, B43, B49, B57, D2, E1, E2, E14, E16, E20, E21, E23, E24, F2, F9-F11, F16-F18, G1, G5, I3, I4, I6, J1, J2, K1, K5, K8, K16, K20, K21, K30, K35

Europe/United Kingdom: A27, A34, A45, C1, E3, E6, E12, E15, G4, H4, J3

India: A2, A6, B12-B14, B21-B25, B32, B37-B39, B45-B50, B53, B54, B56, B58, C3, E11, J7, K6, K29, K33

Africa: A19, B1, B5, B19, B26, B42, B59, F8

Asia: B11, B17, B34, B35, B36, B40, B44, F5, F12, I1, K37

REVIEW OF ECONOMIC LITERATURE

Four categories of studies emerge from the economic post-harvest literature: (1) loss assessment methodologies, (2) secondary source references, (3) unsupported evaluations, and (4) economic analyses. Loss assessment methodologies pertain to discussions on the development of a standardized procedure to assess physical and

economic losses. Secondary sources present estimates of economic losses often referenced from other sources. Several of these primary sources were subsequently included in the annotations. Information on monetary estimates of losses has been included, but these estimates are neither described nor discussed thoroughly enough to determine how the values were derived. This category of information presents both procedures and the resulting monetary loss estimates of economic analyses.

Studies falling into the category of loss assessment methodology generally contain no economic data, but they address the question of standardized steps to use in assessing food losses. Most of this material is devoted to discussing the practices used to measure the physical amount of food lost; it is focused primarily on grain loss assessments. Adams (B3) has developed a grain loss assessment method employing both quantity and quality loss concepts. Quantitative losses have been defined as physical reductions (changes in volume or weight) of a commodity. Qualitative losses have been considered as changes in nutrition or esthetics that are fairly subjective measurements, depending on the orientation of the analyst. In evaluating the combined worth of quality and quantity losses, Adams (B3) has suggested using the potential use of the lost grain as a proxy to derive the economic value of the loss. De Lima (E9), in a critique of Adams' work, has pointed out that physical loss measurements can be done more simply.
De Lima (E9) has argued that regional priorities for grain use must be accounted for in the assessment process. He has used the foreign exchange value of lost grain to evaluate losses. However, neither Adams (B3) nor De Lima (E9) has fully explained his rationale for using these economic value measures. In other research into methods for estimating losses, Shuyler (A45) has advocated developing a standard and precise method of loss assessment, but presents no alternative of his own. Harris and Lindblad (B28) have derived formulas on grain loss evaluation by defining losses as monetary value changes resulting from physical changes. They have also developed formulas for evaluating weight losses and quality degradation in storage. They discuss both changes in value as grain moves through the food system and the economic effects of various government agricultural policies in relationship to converting loss evaluations into monetary terms.

The second category, secondary sources, contains economic values drawn from other sources. One reason for noting this group of literature is to illustrate that economic values derived before 1970 have been frequently cited since 1972 without updates of original estimates. Thus, post-harvest losses are often analyzed on a limited data base that appears not to be expanding. Examples of articles falling into this category are those by Christensen (B16), Bull (A10), Girish (B22), and Wu (D2). Other cases of using outdated measures are data cited by Brett-Crowther (A9) and Pimentel (A37) that were attributed to an article by Parpia (A35) which, in turn, referenced the reported values to a 1962 publication. Majumder (A29) has also used these same 1962 values.

Kaplan (K16), Teng and Krupa (A46), the Association for Science Cooperation in Asia (A5), Kramer (A26), and Sohi (J7) all contain evaluations of U.S. fruit and vegetable losses drawn from Losses in Agriculture, a 1965 study by USDA's Agricultural Research Service (A48). In some cases, such as the U.S. Government Accounting Office (A51), D. Singh (B52), and the Food and Agriculture Organization of the United Nations (FAO) (F4), Hillman (B30), and Bourne (A8), the primary source of economic information is too vaguely cited to trace to an original source. The source cited in Borgstrom (A7) is not included in this bibliography as it was not sufficiently concerned with food losses. However, primary sources cited by Herzka (A20), the Office of Technology Assessment (A32), Mphuru (B41), and Brett-Crowther (A9) that were both recent and relevant have been included in this bibliography.

Unsupported evaluations, the third category, offer neither substantial discussion nor explanation for the economic values they present. Monetary evaluations range from estimates presented without any discussion to estimates referenced to the author's previous work. Both these cases are illustrated by two articles written by Hall (A17, B26). In his report for FAO (B26), Hall presents values for rodent-caused damages at central grain depots, but these values seem not to be part of any particular study. Hall (A17) has vaguely referred to his own earlier work in presenting monetary values for Guyanese rice-milling losses.

While pointing out that assessment values of economic loss are not standardized, Pingale (B45) has given rupee values for annual rat damages in India without explaining the economic factors he used to derive the estimates. Conway (F2) has presented estimates of damage by the medfly in California's fruit and vegetable industries that the University of California's Cooperative Extension Service developed for USDA. Conway has provided little procedural information on the method he used to make the estimates. The Agricultural Research Service (A48) has annually estimated total U.S. field and horticultural crop losses without giving details on the economic magnitude or implications of these losses.

Greig (E12) has suggested expressing potato, barley, and sugar beet losses in terms of the next best use of the land; he has made a monetary estimate, but has not analyzed these losses. Pantastico (F10) has given the value of fruit and vegetable losses in the Philippines, but has not described how these values were obtained. The Association for Science Cooperation in Asia (A5) has estimated Thai rice paddy losses, Indian grain handling and storage losses, and Australian fresh fruit losses without discussing the basic economic factors. Similar studies lacking explanations of how values were derived were conducted by Adhaoo (B8) (an annual Indian food-grain loss value), Aggarwal (A2) (the benefits of scientific grain storage in India), and Garg (E11) (the rupee value of potato storage losses).

In an extreme case, Fung and Rathje (A15) have used a monetary value for U.S. household losses in their title, but have not discussed monetary evaluations in their text. A final example of poorly supported evaluations can be found in Zaehringer (A55) whose estimates of phase-by-phase U.S. food system losses are said to be based on undefined typical loss values.

The final category of economic material found in the literature offers a range of economic analyses of post-harvest food loss situations. Adams (B3) and De Lima (B19) have examined African maize losses using their respective assessment methodologies described earlier. Adams (B3) has used the potential use price of lost maize, and De Lima (B19) has employed the foreign exchange value to evaluate annual maize losses in rural African farming communities. As with most economic estimates, the results are not comparable because of different study conditions, particularly differences in measuring the amount of physical loss. Prasad (B47) has basically side stepped this task by using the annual financial statements of the Food Corporation of India to estimate the rupee value of transportation losses for Indian grain.

Many economic analysts base their evaluations on some sort of market price, however vaguely price is defined. For example, Sprouse and Smith (B55) have used farmers' market prices for corn and soybeans to evaluate onfarm storage losses. Sparks and Summers (E24) have used typical prices received by Idaho farmers at harvest to derive values for stored potato losses in weight and quality. Parpia (A35) has employed average farm prices to find the value of U.S. losses in cereals and legumes. Lockhart (G5) has used local market price to evaluate apple rot losses and their impact on annual sales revenues. By using long-term wheat prices,

Woolcock and Amos (B60) have derived the value of grain losses during handling and transportation and the value of the resulting degradation; they have determined the difference between the original value and the damaged value of grain as its value for pig food. Alvarez (J2) has evaluated the mainland marketing losses due to transportation of Hawaiian papayas using the per-pound retail value of papayas in California. Finally, Bancroft and others (K1) have evaluated the benefits of different sanitation strategies for lemon packinghouses by evaluating the discounts received for decayed fruit arriving at market.

Many analysts use generalized market prices. Abuor (B1) has used the minimum market price to find the value of Kenya's annual loss in national income from grain eaten by weevils. Theophiulus (E25) has provided a statistical review on storage losses of potatoes, beans, peas, and grains; he has evaluated losses using British market prices and has given the value of these losses in terms of the balance of international trade. Parpia (A36) has evaluated various U.S. post-harvest crop losses using an annual average price of U.S. cereals. Sparks (E22) has valued potato losses due to bruising, which either reduces the grade or entirely wastes the product, for the 1976 U.S. market at $100 million.

Shejbal (B51) has derived the value of grade changes of U.S. grain during storage and the values of grain lost in different kinds of storage facilities, using an average market price determined by "experience and literature." Heid and Aldis (B29) have used common discount factors from country grain elevators and the 1979 average U.S. market price to evaluate long-term corn storage losses for both quantity and quality (down-grading) losses. Cramer (A13) uses crop prices in large exporting nations to evaluate numerous losses in world and regional crops without making a distinction between onfarm and post-harvest losses.

After the introduction of freshness dating for perishable goods in supermarkets, the Marketing Economics Division of USDA's Economic Research Service (A49) and the American Association of Cereal Chemists (A4) have used retail market values to evaluate loss levels and reductions. Food losses occurring after goods have been purchased are evaluated in several articles by Rathje, Harrison, and others at the University of Arizona (Rathje (A39), Harrison and others (A19), Rathje and others (A41), Rathje and Harrison (A40). The Tucson residuals analysis project has evaluated local household food losses by various food groups and by household characteristics using local supermarket prices. The group has estimated total household food losses for Tucson at $11 million in 1974.

Several government agencies have contributed analytical economic information. Working for the Australian Bureau of Agricultural Economics, Connell and Johnston (B17) have derived the cost of stored grain losses to insects as a function of the cost of storage facilities and infestation treatments. USDA's Human Nutrition Information Service (F14) has used 1967-77 survey data to estimate losses in vegetable crops due to changes in chemical preservative practices. California's Division of Plant Industry (A11) has utilized annual market prices to evaluate pest damages to California crops. Using loss quantity data from Losses in Agriculture (A48) and constant market dollars, the Government Accounting Office (A50) has evaluated U.S. food product losses in each post-harvest phase from production to consumption. Although Losses in Agriculture has been a major source of loss quantity data, some analysts have made summary economic evaluations by using the average price received by farmers as well as a quality loss factor in their loss assessment equations. As pointed out earlier, this 1965 USDA study has been widely referenced despite the fact that no one has updated loss estimates; the usefulness of many post-harvest loss evaluations based on estimates from this source are considered suspect.

A more recent and equally important work was published by the National Academy of Sciences in 1978 (A31). Volume I includes chapters on commodity losses in developing countries. The Academy has defined losses as reductions in available food that are economically worth mitigating; it has analyzed commodity losses on this basis using market values for a cost/benefit type of analysis. Volume II provides an extensive bibliography.

Reproducible analytical work has been neglected. The literature provides fragmented, incomplete, and noncomparable information on loss values. The lack of a standard economic conceptual framework causes problems in three areas: (1) defining losses (alternative physical assessment practices), (2) tracing food losses through the entire food system (from whole wheat to all wheat products and their marketing and utilization), and (3) making accounting decisions (following changing food values through the food system). However, some works have defined methods and have examined the effects of physical losses on actual revenue; for example, Bancroft (K1) and Lockhart (G5) have shown that economic evaluations can be coordinated with physical loss studies and that economic revenues can be increased if post-harvest losses are reduced.

To provide more decisionmaking information to those who can reduce physical food losses, scientists and economists need to work together to design studies showing not only how such losses can be reduced but also whether that reduction is a sound economic undertaking.

ANNOTATED BIBLIOGRAPHY

A. General

(A1) Adelson, S. F., I. Delaney, C. Miller, and I. T. Noble. "Discard of edible food in households," Journal of Home Economics, Vol. 55, No. 8, Oct. 1963, pp. 633-38.

Focuses on edible discarded foods in three U.S. communities in 1959-66. Data include tables on food energy and nutrient fat calorie losses in each area for seven food groups, the percentage and weight of nine food groups, and selected foods discarded in two communities over 2 weeks. (Refs.)

(A2) Aggarwal, V. S. "Discussants I: Losses in foodgrains in India during storage and transportation," Some Issues Emerging from Recent Breakthroughs in Food Production (ed. K. L. Turk). Ithaca, NY: Cornell University, New York State College of Agriculture and Life Sciences, 1971, pp. 352-59.

Describes the status of loss assessment methodology, estimations, and practices in India. Makes a reasonable estimate of average storage and transportation percentage loss. Includes some discussion of market values as an example, but not as empirical data. (No refs.)

(A3) Allen, J. W., and T. R. Pierson. "Study of food losses in the distribution phases of the U.S. food system," Journal of Food Distribution Research, Vol. 9, No. 1, Feb. 1978, pp. 96-98.

Describes a study on the nature and extent of losses and taste in the U.S. food system. Identifies major issues and factors in food losses and solicits information to supplement available information on this topic. (No refs.)

(A4) American Association of Cereal Chemists. "Open dating and food waste," Cereal Foods World, Vol. 24, No. 10, 1979, pp. 504-06, 512-13.

Discusses wastage of food products in the retailing and consumer phases resulting from labeling products with "freshness" dates. Describes losses in dairy, bakery, and fresh product goods, giving the observed amount and dollar value of out-of-date food. Although most data involve dairy products, gives monetary loss figures for food retailers and food producers. (No refs.)

(A5) Association for Science Cooperation in Asia. "Food--post-harvest and processing technology: Proceedings of an Association for Science Cooperation in Asia Seminar, 1975," Food Technology in Australia, Vol. 27, No. 11, Nov. 1975, pp. 449-500.

Discusses various low-cost/low-energy technologies for reducing losses in several Asian crops. Features fruit, grain, and vegetable crops in several articles. Results include the dollar value of stored grain lost annually in Thailand; the percentage of crop loss during storage for several specific crops; the percentage of weight loss, rot, and sprouting of potatoes and onions after irradiation treatments; and the dollar values of post-harvest wastage of fresh fruit in the United States and Australia. Proceedings conclude with a priority list of loss-reduction projects for government and agricultural officials to consider. (Refs.)

(A6) Bhat, R. V. "Role of post-harvest conservation of foods in achieving nutritional goals," Nutrition and Food Science: Present Knowledge and Utilization, Vol. 2, 1980, pp. 451-55.

Reviews recent developments and findings in loss reduction research and presents a formula for the net present value of investments in post-harvest conservation. A cost benefit analysis uses data on Indian grain losses, including the rupee investment needed to decrease food grain losses by 50 percent, and the annual tons of grains lost in storage. (No refs.)

(A7) Borgstrom, G. "Waste and losses on the world food scene: Neglected aspects," Proceedings of Symposia, IX International Congress of Plant Protection, Washington, D.C., August 5-11, 1979. Volume I: Plant Protection: Fundamental Aspects (ed. Thor Kommedahl). Minneapolis: Burgess Publishing Co., 1981, pp. 17-21.

Discusses the development of food wasted or lost as a resource for increasing the world food supply. Defines food losses and identifies six topics affecting food losses, including post-harvest utilization. Gives figures on the amount of pre-harvest waste and the dollar value in some grain crops. (Refs.)

(A8) Bourne, M. C. "Postharvest food losses--the neglected dimension in increasing the world food supply." Cornell International Agriculture No. 53. Ithaca, NY: Cornell University, New York State College of Agriculture and Life Sciences, Apr. 1977.

Defines post-harvest losses, reviews methods of food preservation, and outlines several programs for loss reduction ranging from loss surveys to technical research. Presents case study of Australian wheat losses containing economic values; however, most discussions of loss use data on percentage loss. (Refs.)

(A9) Brett-Crowther, M. R. "Median objectives in the world problematic," Ecology of Food and Nutrition, Vol. 9, No. 3, 1980, pp. 179-88.

Discusses the role of food, energy, and other resources in world politics, particularly in the less developed countries in the late seventies. Presents numerous estimates of the percentage of food wasted in the post-harvest stage for various crops and countries, especially grains in less developed regions. Gives monetary values for some loss estimations and cites many studies of post-harvest practices. (Refs.)

(A10) Bull, J. O. "Rodents and food spoilage," Chemistry and Industry, No. 22, Nov. 17, 1973, pp. 1056-57.

Discusses both direct and indirect impacts of rodents on food harvesting and handling. Gives general loss estimates for world or national losses in percentage of crops or dollar value. Includes some experimental data on the percentage of grain fouled by rats with and without baiting. Discusses legislative options to control rodents, especially as to costs to the food industry. (Refs.)

(A11) California State Department of Food and Agriculture, Division of Plant Industry. Estimated Damage and Crop Loss Caused by Insects and Mite Pests. 1974-77.

Contains a statistical review of California agriculture and field loss estimates attributable to particular insect pests. Gives yield loss, control costs, percentage of crop value and overall loss estimates in dollar values. Similar data are also available on pest losses incurred at storage facilities. Report includes a table on pest damages and pest control costs for different regions and crops. (No refs.)

(A12) Chiarappa, L. (ed.). Crop Loss Assessment Methods: FAO Manual on the Evaluation and Prevention of Losses by Pests, Diseases, and Weeds. Food and Agriculture Organization of the United Nations, 1971, with supplements No. 1 (1973) and No. 2 (1977).

Catalogs crop-specific loss problems and prevention methods. Discusses methods for reducing and measuring losses due to wild buckwheat in wheat crops, citrus rust mite on citrus, black leaf streak on bananas, and sickle pod in soybeans. Crop loss assessments focus on field and laboratory experiments. (Refs.)

(A13) Cramer, H. H. "Plant protection and world crop production," Pflanzenschutz-Nachrichten "Bayer," Vol. 20, No. 1, 1967, 524 pp.

Surveys and discusses world crop production and loss levels. Discussion centers on crop losses for grains, potatoes, sugar beets, vegetables, fruits, coffee, and cotton and by specific crop pests. Contains much data on losses in various countries, often providing monetary estimates. (Refs.)

(A14) Dilley, D. R. "Approaches to maintenance of postharvest integrity," Journal of Food Biochemistry, Vol. 2, No. 3, 1978, pp. 235-42.

Describes methods of controlling storage atmosphere content, such as plastic films, gas atmosphere generators, liquid nitrogen purging systems, and low-pressure storage. (Refs.)

(A15) Fung, E. E., and W. L. Rathje. "How we waste $31 billion in food a year," Food from Farm to Table: USDA Yearbook of Agriculture. U.S. Department of Agriculture, 1982, pp. 352-57.

Discusses attempts at the University of Arizona to study levels of household food loss through residual analysis of household garbage. Evaluates waste-level factors such as income level, ethnicity, general environment, incidence of working mothers, types of food purchased, and cultural habits as to food appearance or use of leftovers. Includes percentage figures on amounts of home food waste. Makes no monetary estimates of losses to support figures included in the title. (Refs.)

(A16) Genel, M. R. "Successful methods for reducing losses during storage in tropical environments," Some Issues Emerging from Recent Breakthroughs in Food Production (ed. K. L. Turk). Ithaca, NY: Cornell University, New York State College of Agriculture and Life Sciences, 1971, pp. 319-25.

Identifies and discusses remedies for the major causes of post-harvest loss, such as storage structures, conditions, and pests. Includes limited number of estimates on percentages of crops lost due to given causes. (Refs.)

(A17) Hall, D. W. "Handling and storage of food grains in tropical and subtropical areas." Agricultural Development Paper No. 90. Rome: Food and Agriculture Organization of the United Nations, 1970.

Includes a general discussion of national agricultural economics and marketing regarding food storage and basic profit margin analysis of storage practices. Includes dollar values for storage equipment. Monetary estimates of storage loss include the dollar value of losses due to rodent attack on sacks of grain at central depots. Report also presents results on weight losses and insect-caused losses indexed by commodity, country, and percentage of crop lost. (Refs.)

(A18) Harrison, G. G., M. C. Mapes, and W. L. Rathje. "School studies of food waste as a tool for nutrition education," Illinois Teacher, May/June 1976, pp. 298-304.

Describes the usefulness of using food wastage studies as a nutrition education exercise in elementary and secondary schools. Summarizes the refuse study conducted by the University of Arizona at Tucson. Includes the results of three elementary or secondary school projects inspired by the Tucson Garbage Project. Gives model guidelines for using food wastage projects. Data from elementary projects include the total weight of wasted food in a given period, the absolute number of food items wasted, and the content percentages of total waste in school cafeterias. (Refs.)

(A19) Harrison, G. G., W. L. Rathje, and W. W. Hughes. "Food waste behavior in an urban population," Journal of Nutrition Education, Vol. 7, No. 1, Jan./Mar. 1975, pp. 13-16.

Reviews findings of a study on household refuse in Tucson, AZ. Discusses the advantages of studying refuse, the study methodology, and its results. Presents results on the percentage of waste from total annual food inputs, the percentage of various kinds of waste (reducible/nonreducible), and the percentage of specific food products wasted. Provides the annual cost of specific food products wasted and the total annual cost of wastes per individual household and for the entire area. (Refs.)

(A20) Herzka, A. (ed.). "Post-harvest food crop conservation," Progress in Food and Nutrition Science, Vol. 4, No. 3/4, 1980, 138 pp.

Contains papers presented at a symposium organized by the Association of Consulting Scientists (Hamrogate, England, Nov. 1979). Papers discuss various aspects of the general post-harvest situation, control of endogenous deterioration of food crops, control of exogenous crop losses, and the economic, social, and nutritional effects of conservation. D. P. Singer's paper, "Post-harvest food losses--world overview," contains data on the nutritional needs and production levels for several nations. H. D. Tindal and F. J. Proctor's paper, "Loss prevention of horticultural crops in the tropics," discusses loss assessment methodology and provides estimates on the percentage of crop loss for various crops. (Refs.)

(A21) Hindmarsh, P. S. "Reduction of post-harvest losses to durable produce in Zambia," Tropical Stored Products Information, No. 31, 1976, pp. 13-15.

Describes the Zambian Ministry of Rural Development's work program of surveys, research investigations, training, and extension work in post-

harvest food losses. Estimates percentages of crops lost during handling and storage. (No refs.)

(A22) Hoover, S. R. "Prevention of food-processing wastes," Science, Vol. 183, No. 4127, Mar. 1, 1974, pp. 824-28.

Reviews processing technologies such as peeling, dewaxing, cleaning, blanching, pickling, starch manufacturing, soybean oil refining, and cheese curdling. Quantifies possible changes such as the amount of water used in production, reduction of solid wastes in waste stream, reduction of crop processed in waste stream, and reduced percentage of chemical oxygen demand during processing. Discusses appropriate technologies to promote waste reduction and suggests economically viable alternatives for using waste material. (Refs.)

(A23) Howe, R. W. "Losses caused by insects and mites in stored foods and feeding stuffs," Nutrition Abstracts and Reviews, Vol. 35, No. 2, 1965, pp. 285-303.

Reviews the various definitions of losses, focusing on weight loss caused by insects. Describes methods of estimating weight loss and the factors to consider in making estimations. Places losses in an economic context, distinguishing between real losses and changing preferences by food purchaser. Concludes that in some cases the cost of maintaining quality is too high to make it economically feasible.

(A24) _____. "Some obvious and not so obvious sources of post-harvest-loss," Proceedings of 8th British Insecticide and Fungicide Conference, Vol. 3, 1975, pp. 975-80.

Generally discusses the food loss problem. Makes no specific economic evaluations, but includes some estimates on national annual crop loss in England at the farm level (percentage of weight lost in storage). Presents a case study of storage losses in dry weight of Nigerian groundnut crop. The author focuses on the difficulties of estimating losses. (Refs.)

(A25) Kahn, S. G. "World hunger: An overview," Food Technology, Vol. 35, No. 9, Sept. 1981, pp. 93-98.

Discusses future world food supplies, production, and needs with special emphasis on developing nations. Mentions post-harvest loss reduction as a way to increase available food supplies by 10-20 percent. Mentions several international programs that examine post-harvest losses. Estimates national food production levels and world food need levels. (Refs.)

(A26) Kramer, A. Food and the Consumer. Westport, CN: AVI Publishing Co., Inc., 1980, 220 pp.

Discusses consumer food utilization. A chapter on waste disposal and utilization contains percentage figures on the amount of harvested food actually utilized after handling and processing. Other data include the tons of tomatoes annually wasted in the United States and USDA's dollar value for vegetable losses. (Refs.)

(A27) Lawrie, R. A. "Waste in the food system," Proceedings of the Nutrition Society, Vol. 36, No. 3, 1977, pp. 275-83.

Reviews food loss problems in the harvesting, processing, and consumption phases of the food system. Although most data involve animal products, the author discusses losses of fresh fruit and vegetable producers. Gives the percentage weight and nutrient losses due to trimming and preparation processes. (Refs.)

(A28) Lipton, M. Research into the Economics of Food Storage in Less Developed Countries: Prospects for a Contribution from U.K. Technical Assistance. Communications Series No. 61. Brighton, England, University of Sussex, Institute of Development Studies, 1971, 16 pp.

Summarizes food storage literature, fieldwork, and analytic cost-benefit evaluations of the economics of crop losses. Recommends that research be directed to solving problems of grain crops in India. Provides data such as the percentage of various crops lost in storage worldwide and in specific nations, the British pound value of these losses in some cases, and the rates of return for various investments in loss reduction. Includes an example of the British pound value of net social benefits of a new storage system. (Refs.)

(A29) Majumder, S. K. "Pre-harvest and post-harvest losses," in Bread: Social, Nutritional and Agricultural Aspects of Wheaten Bread (ed. A. Spicer). London: Applied Science Publishers, Ltd., 1975, pp. 181-99.

Discusses the nature and extent of losses in both pre- and post-harvest stages of food production. Addresses the general problems of post-harvest infestation by insects or rodents (uric acids, body fragments, and food borne diseases), quantitative and qualitative loss assesssment, and methods of minimizing loss for some specific goods. Tables present loss estimates from various countries giving: (1) percentage of crop lost or a dollar value of crop lost, (2) percentage of total losses occurring in the pre- and post-harvest stages for several countries, (3) estimates of preventable losses, and (4) percentage of various contaminants found in ground wheat and rice. (Refs.)

(A30) Morris, R. F. Postharvest Food Losses in Developing Countries: A Bibliography. Washington, DC: National Academy of Sciences, 1978.

Contains over 2,000 citations on post-harvest losses, some of which are annotated. Categories include general food loss and control, methodologies for food loss assessment, general grain losses, maize, rice, wheat, other grains, pulses, fruits and vegetables, roots and tubers, fish, specific food loss reduction procedures, training for reducing losses, additional information sources, and economics. Bibliography includes author and country indexes. (Refs.)

(A31) National Academy of Sciences. Postharvest Food Losses in Developing Countries. Washington, DC, 1978.

Reviews the status of the post-harvest food losses of numerous developing nations. Addresses cultural and socioeconomic aspects; loss assessment and estimation of losses for grains, legumes, perishables, and fish; and the

education and training available to reduce losses. Provides extensive economic analysis, evaluation, and estimates of post-harvest losses. (Refs.)

(A32) Office of Technology Assessment. Agricultural Post Harvest Technology and Marketing Economics Research: A Technical Memorandum. Apr. 1983, 118 pp.

Reviews public and private research on post-harvest technology and marketing economics. Describes both sectors' research organizations, expenditures, and topics. Discusses applications and benefits of research findings. Mentions the National Academy of Science's study on post-harvest food loss and loss evaluations. (Refs.)

(A33) Osner, R. "Food wastage," Nutrition and Food Science, Vol. 77, 1982, pp. 13-16.

Discusses food energy losses in the United Kingdom. The author includes the percentage of wasted crops at different phases of the food system and the percentage of nutrient losses in some situations. Waste levels from educational institutions are the special focus of the study, which also discusses waste reduction practices. (Refs.)

(A34) Parkin, E. A. "Stored Product Entomology," Annual Review of Entomology, Vol. 1, 1956, p. 223.

Assesses the losses caused by insects to stored food products. Discusses the different types of loss estimates, general and experimental, including a review of studies using these approaches. Examines the limitations of current assessment methods, especially the comparability of available estimates of loss.

(A35) Parpia, H. A. B. "More than food would be saved," Ceres, Vol. 10, No. 6, Nov.-Dec. 1977, pp. 19-24.

Discusses post-harvest losses in the world food system. The author uses percentage of national crop loss and figures on weight to derive monetary estimates of cereal and legume losses. Discusses objectives for improving the food systems of developing nations. (Refs.)

(A36) _____. "Postharvest losses--impact of their prevention on food supplies, nutrition, and development," Symposium on Nutrition and Economic Development in the Tropics, Guatemala, 1974: Nutrition and Agricultural Development. New York: Plenum Press, 1976, pp. 195-206.

Surveys post-harvest losses due to insects and rodents in grains, rice, legumes, and perishable goods. Analyzes methods of reducing losses. Presents results on the percentage of loss due to decay or contamination after different treatments. One table contains dollar figures assigned to losses in certain U.S. crops. (Refs.)

(A37) Pimentel, D. (ed.). World Food, Pest Losses, and the Environment. Boulder, CO: Westview Press, Inc., for the American Association for the Advancement of Science, 1978.

Contains three articles on post-harvest food losses. A general discussion focuses on methods used to calculate losses. Presents a case study on the

causes for post-harvest loss in Mali millet and the various methods of minimizing losses, such as granary construction and maintenance. Gives loss quantities in percentage of granary, percentage of moisture, cost in storage, and kilograms of loss in production. A discussion follows of why post-harvest loss research is a high priority at the United Nations. Presents percentages and monetary values of losses in certain crops as evidence of the need to continue research. (Refs.)

(A38) Polopolus, L. "Agricultural economics beyond the farmgate," American Journal of Agricultural Economics, Vol. 64, No. 5, Dec. 1982, pp. 803-10.

Addresses the important economic problems that occur in the food production system after food and fiber leave the farm. Stresses the value added to food, roughly twice that of production agriculture, as it passes through the food-marketing system. Post-harvest food losses become more costly to society than food losses at the farmgate.

(A39) Rathje, W. L. "Food utilization and discard at the household level: A view from the garbage can," Key Issues in Population and Food Policy. Capon Springs Public Policies Conference No. 2. Washington, DC: University Press of America, 1978, pp. 282-85.

Discusses food losses in the household. The author describes "le Project du Garbage," a long-term study measuring the actual amount of food wasted by households in the Tucson, AZ, area. Attempts to analyze patterns of food use processing, delivery systems, and family sociodemographic characteristics. Outlines three steps necessary to reduce household food losses and indicates that 40 percent of all post-harvest food losses, with an estimated value at $11.5 billion annually, occur in the household. (Refs.)

(A40) _____, and G. F. Harrison. "Monitoring trends in food utilization: Application of an archaeological method," Federal Proceedings: Federation of American Societies for Experimental Biology, 1978, Vol. 37, No. 1, Jan. 1978, pp. 49-54.

Discusses the use of archeological techniques to study household food wastage in a 1973-75 Arizona study. Project results include the annual food input weight, percentage and cost of losses in various foods groups for four levels of income groups. Lower income homes tend to waste less food than do higher income homes. Discussion focuses on behavior changes due to national economic and social conditions, like inflation, affecting food use levels such as eating out or recycling leftovers. (Refs.)

(A41) _____, W. W. Hughes, S. L. Jernigan, and G. G. Harrison. "Food loss at the household level: A perspective from household residuals analysis," Proceedings of the Second Symposium on Research Applied to National Needs. National Science Foundation. Washington, DC, Vol. 2, Nov. 7-9, 1976, pp. 32-35.

Discusses the development and content of three data bases on the level of household food wastage in Tucson, AZ. Discusses the issues involved in modifying consumer behavior or the food system itself to reduce waste levels and the need for comprehensive quantitative models. Quantitative and economic data consist of general estimations of the total value of U.S. wastage based on the percentage of wastes found in the study. (Refs.)

(A42) Reusse, E. "Economic and marketing aspects of post-harvest systems in small farmer economies," Monthly Bulletin of Agricultural Economics and Statistics, Part 1, Vol. 25, No. 9, 1976, pp. 1-7; Part 2, Vol. 25, No. 10, 1976, pp. 1-10.

Discusses the general economic factors in the storage, processing, and transportation systems of developing countries, featuring such topics as the role of public facilities in determining the costs of post-harvest operations. Includes loss data on the percentage of various crops lost in different storage situations in selected countries. (Refs.)

(A43) Revelle, R., A. Khosla, and M. Vinovskis. "Losses and protection of food: Report of the panel on the world food supply," The Survival Equation: Man, Resources, and His Environment. Boston: Houghton Mifflin Company, 1971, pp. 257-72.

Generally describes food loss problems, their extent, causation, prevention, and impact. Contains data for several developing countries and for grain crops, specifically the losses in damage (percentages) and in weight over given storage periods. Cites several losses in percentages for various crops nationally and worldwide and gives some costs of loss prevention (for example, refrigeration). (Refs.)

(A44) Roy, R. Wastage in the U.K. Food System. London: Earth Resources Research, 1976, 42 pp.

Examines the causes and amounts of food losses in phases of the United Kingdom food system from farm gate through consumption. Defines food losses and notes that eliminating all losses would be uneconomical. Gives percentage figures for weight and nutrient losses in specific crops due to various causes at different points in the food system. (Refs.)

(A45) Shuyler, H. R., G. G. Corbett, E. Reusse, and W. Barreveld. "Action versus its justification: Which comes first?" Proceedings of the 15th International Congress of Entomology, 1976, pp. 705-07.

Discusses the current state of post-harvest loss assessment and loss assessment methodology, pointing out that insufficient resources are available for governments to develop scientific justifications for loss reduction program goals. Suggests that study requests to FAO be funded regardless of imprecise information on needed resources or potential benefits and suggests that loss survey methodologies be developed, used, documented, and evaluated. (No refs.)

(A46) Teng, D. S., and S. V. Krupa. Crop Loss Assessment Proceedings of E. C. Stakman Commemorative Symposium. Miscellaneous Publication 7. University of Minnesota, Agricultural Experiment Station, 1980.

Contains considerable economic quantification of losses; however, makes few distinctions between pre- and post-harvest losses. Papers cover such topics as the economic, social, and political implications of crop losses; measuring yields, losses, and intensity of biotic and abiotic factors; crop loss models; crop loss assessment and integrated pest management; economic analysis in crop loss research and application; esthetic, economic, and recreational impacts of biotic and abiotic factors on natural ecosystems; and assessment of post-harvest grain losses. (Refs.)

(A47) U.S. Department of Agriculture, Agricultural Research Service. Insect Control in Marketing. ARS-NRP, No. 20620. Oct. 1976, 80 pp.

Describes a national research program on insect control practices during the marketing stages of field, horticultural, and animal products. Defines program purpose and goals and describes post-harvest insect problems. A review of literature on insect losses includes loss evaluations from USDA Handbook 291 (see A48). Evaluates current and future research directions and impacts for each of the three product classes. Presents data on the dollar value of losses in each class in 1975 and gives various figures of amounts or percentage losses in grains and other crops. (Refs.)

(A48) _____. Losses in Agriculture. Agriculture Handbook No. 291. Aug. 1965.

Discusses storage losses in 30 commodities and 10 field crops. Study includes monetary values and quantity data on losses due to insects during storage. Data losses in marketing and processing selected fruits and vegetables include quantity and dollar value estimates of losses in transit and during retail marketing. Report gives estimated average annual losses in processing in quantity and dollar figures for 5 field crops, 20 fruit crops, and 17 vegetable crops. Includes dollar values for the cost of controlling insects in stored products for 18 commodities. All data are estimates from 1951-60. (Refs.)

(A49) U.S. Department of Agriculture, Economic Research Service, Marketing Economics Division. Food Dating: Shoppers' Reactions and the Impact on Retail Food Stores. Marketing Research Report No. 984. Jan. 1973, 76 pp.

Examines the effect of different types of open (uncoded) dating on fresh retail goods. The results of the study show decreased economic and product losses in supermarkets where open dates were used and in those where improved food-handling practices were emphasized. Gives percentages of various product losses due to rehandling (returned goods) and losses as a percentage of sales. (No refs.)

(A50) U.S. Government Accounting Office. Food Waste: An Opportunity to Improve Resource Use. CEC-77-118. Sept. 16, 1977, 75 pp.

Reviews the overall food loss situation in the United States during harvesting, storage, handling, and consumption, focusing on the implications for Federal policy. Uses weight and dollar losses to measure the extent of losses. Notes the availability of information on storage, transportation, processing, retailing, consumption, and household phases, and presents data for 1974. Gives the dollar value and tonnage of several crops lost in each phase of the food system and the total dollar estimates of total losses in each phase. The largest dollar losses are at the household level. Discussion focuses on losses due to other factors (such as labor strikers) and the need for more research on loss reduction. Research problems include cost of research and percentage reductions in costs or weight loss at each post-harvest phase. Report reviews the impacts of loss reduction on world hunger, the economic disincentive of business to reduce losses, and possible Federal policy recommendations. Includes an appendix on the calculation of loss values in each phase. (Refs.)

(A51) _____. Hungry Nations Need to Reduce Food Losses Caused by Storage, Spillage, and Spoilage. ID-76-65. Nov. 1, 1976, 29 pp.

Discusses the need for U.S. agricultural aid programs to developing nations to reduce losses and to increase production. Gives several estimates of the amount of foods lost from various causes and during different phases of food handling. Food losses in India are estimated at $1 billion for 1972. The report notes that loss estimates are not based on enough data and are generally unreliable. (Refs.)

(A52) _____. What Causes Food Prices to Rise? What Can Be Done About It? CED-78-170. Sept. 8, 1978, 154 pp.

Discusses causes and factors of rising U.S. food prices. Mentions the roles of insects and other post-harvest pathogens and estimates the amount of cereal grains lost annually to insects. Notes reduction of food losses as a tool for stabilizing food prices. (Refs.)

(A53) Watters, F. L., and H. R. Shuyler. "Control of post-harvest food losses," FAO Plant Protection Bulletin, Vol. 25, No. 4, 1977, pp. 184-88.

Reviews the Food and Agriculture Organization of the United Nations (FAO) post-harvest loss activities: past, present, and future. Introduction includes estimates of the percentage of national crop losses in the stored grain and maize products of tropical and subtropical regions. Discusses the direction of FAO programs, but presents no specific results. (Refs.)

(A54) Zadoks, J. C., and R. D. Schein. Epidemiology and Plant Disease Management. New York: Oxford University Press, 1979.

Discusses "Disease and Crop Loss Assessments" in chapter 8. Economic considerations are noted to be factors of supply and demand that were unsuitable for the scope of the text. The rest of the chapter defines and describes loss assessment terms, techniques, and predictive and useful values of such techniques. (Refs.)

(A55) Zaehringer, M. V., and J. O. Early (ed.). Proceedings of National Food Loss Conference, Sept. 12-15, 1976, Boise, Idaho. University of Idaho-Moscow, College of Agriculture, 1976, 142 pp.

A collection of papers on overall (not just post-harvest) food losses. Of special interest are papers addressing economic issues, social impacts, monetary losses in grain storage, impact of regulatory activities, and use of environmental control to reduce storage losses. (Refs.)

B. Grains, Cereals, and Pulses

(B1) Abuor, C. O. "Weevils cost Kenya £1,000,000," Kenya Farmer, Vol. 170, Aug. 1970, p. 7.

Describes an insecticide demonstration project on small Kenyan farms. The project attempted to illustrate the economic and quantitative savings of chemically treating stored grain to protect it against weevils. The results

show the increase in weight of stored maize after treatment, the number of bags lost annually in one province, and the national income lost because of weevil damage. (No refs.)

(B2) Adams, J. M. "A bibliography on post-harvest losses in cereals and pulses with particular reference to tropical and subtropical countries," Report of the Tropical Products Institute, No. G110, 1977, 23 pp.

Contains 265 entries on grain losses in tropical countries. Categorizes entries by type of work, review, or experiment and by level of loss estimate information (provisional, supported, or complete). References are generally not annotated. (Refs.)

(B3) _____. "The evaluation of losses in maize stored on a selection of small farms in Zambia, with particular reference to methodology," Tropical Stored Products Information, No. 33, 1977, pp. 19-24.

Reports the specific losses in quantity and quality of stored maize by integrating grain losses with consumption patterns. Assigns monetary values to the losses and to the costs and benefits of a new storage technique. (No refs.)

(B4) _____. "A guide to the objective and reliable estimation of food losses in small scale farmer storage," Tropical Stored Products Information, No. 32, 1976, pp. 5-12.

Establishes a standard methodology of stored grain loss assessment by using laboratory loss data in conjunction with information on demand levels for grain consumption. Gives no specific economic data but provides tables and graphs. (Refs.)

(B5) _____. "Post-harvest losses in cereals and pulses: The results of a questionnaire survey, June 1976," Tropical Stored Products Information, No. 34, 1977, pp. 23-48.

Summarizes the results from a survey covering the country, commodity, loss situation (place), type of loss, percentage amount, storage period, cause, and other information about post-harvest losses with a statistical description of the survey's response. (No refs.)

(B6) _____. "A review of the literature concerning losses in stored cereals and pulses, published since 1964," Tropical Science, Vol. 19, No. 1, 1977, pp. 1-28.

Reviews and summarizes published work on post-harvest losses of grains and pulses (legumes). The author defines losses and then discusses the literature on both experimental loss estimates and field estimates. Often provides the literature's results on the percentage of weight loss or the percentage of damaged crops. Provides a summary analysis of the total body of reviewed work by a series of graphs showing the amount of work done relating to various types, places, causes, and phases of loss. (Refs.)

(B7) Adesuyi, S. A., and D. A. Shode. "Assessment of losses in two varieties of maize stored in cribs in the humid tropics," Nigerian Journal of Plant Protection, Vol. 3, 1977, pp. 98-107.

Examines losses of stored maize in Nigeria. Gives the percentages of moisture loss, insect damage, and mold growth during storage. Other results include the percentage of totally viable grain and the total weight loss after storage. (Refs.)

(B8) Adhaoo, S. H. "Post-harvest operations: Need for avoiding wastes," Productivity, Vol. 18, No. 2, July-Sept. 1977, pp. 261-67.

Discusses grain losses in each post-harvest phase. The major focus is on alternative procedures to reduce losses at rural levels. Presents data on worldwide crop loss percentages, storage weight loss, and rupee values for annual Indian grain losses. (Refs.)

(B9) Asian Productivity Organization, Agriculture Division. Training Manual: Post-Harvest Prevention of Waste and Loss of Food Grains. Tokyo, 1974, 358 pp.

Covers material on a training course held in New Delhi (Oct. 9 - Nov 5, 1973) on the prevention of waste and loss of food grains. Papers fall into the following categories: post-harvest problems and quality control, grain storage structure and management, food grain storage, storage pests and their control, theory and practice of grain drying, containers and transport of food grains, and processing and use of cereal by products. Although some papers discuss general estimates of the extent of losses, most focus on practices to prevent losses. (Refs.)

(B10) Bagent, J. L. "Fumigate stored rice to reduce loss to insects," Rice Journal, Vol. 72, No. 3, Mar. 1969, pp. 15-16.

Discusses fumigation treatments for rice. The study focuses on the types of insects that attack rice and the appropriate fumigants to use in certain situations. Gives no specific data on the effectiveness of fumigation in reducing post-harvest rice losses. Author estimates 2 percent of stored rice in Louisiana is lost per month to insect pests. (No refs.)

(B11) Banks, H. J. "Effects of controlled atmosphere storage on grain quality: A review," Food Technology in Australia, Vol. 33, No. 7, 1981. pp. 335-40.

Reviews prior work on controlled-atmosphere storage of grains. Describes storage methods and gives the resulting percentage of germination, fungi and mold growth, and infestation. Concludes that controlled-atmosphere storage is beneficial to quality in overall storability. (Refs.)

(B12) Bindra. O. S. "Malathion--its role in the prevention of storage losses," Agriculture and Agro-Industries Journal, Vol. 4, No. 9, Sept. 1971, pp. 38-42.

Discusses problems and uses of fumigants in Indian food grain storage, highlighting the pros and cons of properly using malathion. Includes estimates on food grain saved from loss by this treatment and on general food grain loss in India. (Refs.)

(B13) _____. "Use of malathion as a grain protectant for prevention of storage losses," Pesticides, Vol. 5, No. 12, Dec. 1971, pp. 45-48.

Discusses using malathion as a substitute for DDT and BHC as a grain insecticide in India. Includes figures of the annual storage losses (tons) in food grains and the percentage of grain lost to insects and bad storage. (Refs.)

(B14) Boxall, R. A., M. Greely, and D. S. Tyagi. "The prevention of farm level food grain storage losses in India: A social cost benefit analysis," Tropical Stored Products Information, No. 37, 1979, pp. 11-17.

Reports on an Indian farm study identifying social costs and benefits of improving storage, particularly of rice. Loss data focus on the percentage of dry weight loss per storage container due to insects or other problems and on a 2-year comparison of the effect of storage structure improvements on the percentage of weight lost. (Refs.)

(B15) Champ, B. R., and C. E. Cyte. Report of the FAO Global Survey of Pesticide Susceptibility of Stored Grain Pests. FAO Plant Production and Protection Series, No. 5. Food and Agriculture Organization of the United Nations, 1976, 297 pp.

Surveys pest problems and control practices for grain stored worldwide. Includes information on problems caused by a particular pest species in a nation and the changing percentages of insect resistance to various chemicals in different countries. (Refs.)

(B16) Christensen, C. M. (ed.). Storage of Cereal Grains and Their Products, 3rd ed. St. Paul, MN: American Association of Cereal Chemists, Inc., 1982, 544 pp.

Discusses grain storage issues. Chapters address physical aspects of grain storage, including loss sources such as insects, rodents, and microflora. Book discusses grain-processing practices without mentioning physical losses. Gives loss percentage and dollar value figures. (Refs.)

(B17) Connell, P. J., and J. H. Johnston. "Costs of alternative methods of grain insect control." Occasional Paper No. 61. Bureau of Agricultural Economics, Canberra, 1981, 77 pp.

Examines and compares costs per ton of chemical-controlled, refrigerated, and controlled-atmosphere grain storage. Most costs identified in the study relate to structure and operations of storage facilities. Gives expected costs for infested grain from two different storage structures as 6.6 cents per ton for horizontal structures and 52.7 cents per ton for vertical ones. (Refs.)

(B18) Davis, D. R. "Wheat and nutrition concluded," Nutrition Today, Vol. 16, No. 5, 1981, pp. 22-25.

Compares the nutrient content of different wheat varieties. Estimates that 80 percent of wheat grain nutrients are lost during milling. Gives costs of using whole grains for wheat products as a final argument for using whole grains and shows the lower cost of high-nutrient products compared with the higher cost of processed lower nutrient goods. (No refs.)

(B19) De Lima, C. P. F. "The assessment of losses due to insects and rodents in maize stored for subsistence in Kenya," Tropical Stored Products Information, No. 38, 1979, pp. 21-25.

Identifies inconsistencies in previous loss assessments and applies a methodology designed to adjust assessed values in light of appropriate priorities. Data include the percentage of the subsistence crop lost to insects and rodents, and estimated value of those losses. Results include the total tons of food lost. (Refs.)

(B20) Dendy, D. A. V. "Nutritional losses in processing grains," Nutritional and Food Science: Present Knowledge and Utilization, Vol. 2, 1980, pp. 457-64.

Discusses the importance of accurately assessing nutritional losses in grains. Discusses several situations where losses occur. The nutritional "costs" of vitamins and other nutrients lost because of poor food habits, inefficient cleaning processes, or pest infestation are high. (Refs.)

(B21) Doharey, R. B., P. K. Srivastava, and G. K. Girish. "VIII: Studies on the assessment of losses of wheat in Punjab," Bulletin of Grain Technology, Vol. 13, No. 3, Dec. 1975, pp. 159-61.

Contains a survey of stored wheat losses in India that shows percentage of weight loss, average moisture content, percentage of weeviled grains, and percentage of germ-eaten grains for various kinds of wheat stored in 10 separate storage structures. (Refs.)

(B22) Girish, G. K., K. K. Arora, K. Krishnamurthy. "Studies on rodents and their control; Part X: Storage losses in foodgrains by rats," Bulletin of Grain Technology, Vol. 12, No. 2, Aug. 1974, pp. 139-48.

Describes the extent of rat damage to food grain stores and emphasizes that rats create grain losses by consumption, hair loss, and excrement. Data include the weight or monetary estimation of loss damage in India, the United States, and the Philippines, and the percentage of grain losses for eight grains. Study identifies national losses for five types of loss indirectly caused by rats. (Refs.)

(B23) Girish, G. K., R. K. Goyal, R. P. S. Tomer, P. K. Srivastava, and K. Krishnamurthy. "Studies on preservation of food grains in rural storage structures; Part I: Studies on the preservation and losses of food grains in underground pits (Khatties) in Uttar Pradesh," Bulletin of Grain Technology, Vol. 10, No. 1, Mar. 1972, pp. 11-21.

Compares the effectiveness of two storage structures in minimizing grain storage losses. Loss results include the percentage of damaged grain, the percentage of germinated grain, and the ratio of free fat acidity per 100 grams of grain. (Refs.)

(B24) Girish, G. K., S. K. Jain, A. Kumar, and N. S. Agrawal. "Part V: Assessment of storage losses, quality and pesticidal contamination in wheat available in the markets of Western Uttar Pradesh, Punjab and Haryana," Bulletin of Grain Technology, Vol. 13, No. 1, Apr. 1975, pp. 8-18.

Presents results indicating the extent of loss and contamination by insects in Indian grain stored for market. Estimations from samples show that 25

percent of marketable grain is either lost to contamination or breakage or is reduced in quality by moisture changes. Study reports total storage losses caused by insects in 25 grain markets. (Refs.)

(B25) Girish, G. K., B. P. Tripathi, R. P. S. Tomer, and K. Krishnamurthy. "Studies on the assessment of losses; Part IV: Conventional grain storage practices and losses in rural areas in Uttar Pradesh," Bulletin of Grain Technology, Vol. 12, No. 3, Dec. 1974, pp. 199-210.

Provides data evaluating actual grain quality for grain stores in Uttar Pradesh, India, against quality standards of the Food and Agriculture Organization of the United Nations. Documents the moisture content, percentage weight loss, temperature, and insect presence for each store. (Refs.)

(B26) Hall, D. W. "Storage and protection of rice and paddy in Guyana," Changes in Agriculture (ed. A. H. Bunding). New York: Praeger Publishers, 1970, pp. 687-94.

Describes the Guyanese rice industry. The author identifies the structure and problems of the industry, including storage losses. Gives the percentage of the 1965 rice crop lost in processing and to insects, and evaluates each in British pounds. (Refs.)

(B27) Harein, P. K. "Grain storage management," Farm Store Merchant, Vol. 17, No. 6, June 1974, pp. 48-53.

Discusses stored grain losses due to insects. Discusses reasons for losses, types of losses, types of insect pests, and treatments to reduce losses. (No refs.)

(B28) Harris, K. L., and C. J. Lindblad. Postharvest Grain Loss Assessment Methods: A Manual of Methods for the Evaluation of Postharvest Losses. Washington, DC: American Association of Cereal Chemists, 1978, 193 pp.

Discusses quantitative methods for assessing grain loss. The discussion concentrates on methods to determine the physical loss. However, the authors derive formulas for converting weight, nutritional, and other losses into economic values and monetary terms. (Refs.)

(B29) Heid, W. G. Jr., and D. F. Aldis. Solar-Supplemented, Natural Air Drying of Shelled Corn: The Economic Limitations. TB-1654. U.S. Dept. of Agr., Econ. Stat. Serv., June 1981, 38 pp.

Analyzes a solar corn-drying system with simulated weather data for 20 years. Results indicate that natural airflow systems are more economical than solar systems despite the larger percentage of crops that deteriorate to a lower grade. Study gives the percentage weight loss during storage, the average annual economic loss due to corn quality deterioration in cents per bushel, the equipment investment costs, and the percentage of quality degradation during storage. (Refs.)

(B30) Hillman, D., and T. Logan. "Big-package hay systems." Extension Bulletin E-950, No. 99. Michigan State University Cooperative Extension Service. June 1976, 4 pp.

Discusses onfarm handling and storage losses of hay. Reviews loss studies of different hay-packaging systems and examines the nutritional impact of these losses on dairy cows. Presents data on the percentage of nutrient and weight losses under the different packaging types, and economically evaluates hay quality losses as milk production losses. (No refs.)

(B31) Hirning, H. Grain Drying Tables. AE-94. North Dakota State University--Fargo, 15 pp.

Provides a set of tables to determine the percentage of grain weight loss during drying. The percentage of net dry grain and the percentage of grain shrinkage after storage can be determined from these tables. (No refs.)

(B32) Huysmans, A. A. C. "Storage of foodgrains problems and prospects," Bulletin of Grain Technology, Vol. 8, No. 3, Sept. 1970, pp. 92-97.

Generally describes and assesses post-harvest losses in Indian food grains. Data include losses measured as a percentage of 1962-65 production of eight food grains in different stages of handling and losses measured by different storage pests. Author discusses the costs (in rupees) and prospects for improved storage. (Refs.)

(B33) Janicki, L. J., and V. E. Green, Jr. "Rice losses during harvest, drying and storage," Rice, Vol. 25, No. 4, Dec. 1976, pp. 333-38.

Discusses causes and conditions of common rice losses (birds, insects, rodents, and antiquated handling processes) and appropriate techniques for mitigating losses, including a detailed description of two artificial drying units. Reports the percentage of crop loss estimates for stored cereals and pulses for the world, Latin and South America, Africa, and India. Authors maintain losses could be reduced to a 5-percent level with good storage practices. (Refs.)

(B34) Jepson, W. F. "Main pest control problems in stored products in Asia and the Far East: Economic aspects and pesticide application problems," Tropical Stored Products Information, No. 27, 1974, pp. 7-11.

Discusses pest control problems focusing on fumigation and chemical protections. Gives cost estimates for seven different storage systems. Provide data on capital costs per ton of capacity, site costs per ton of capacity, and total cost of structures per ton per year. (Refs.)

(B35) Johnston, J. H. "Implications of pest control for grain handling: A report to the NSW Grain Handling Enquiry, January 1981." Miscellaneous Bulletin No. 34. Division of Marketing and Economics, New South Wales, Australia, Oct. 1981, 139 pp.

Analyzes grain storage problems, emphasizing insect control. Derives the dollar costs of various insect control methods and grain storage systems. Gives the ton capacities of various facilities and the number of infested facilities. (Refs.)

(B36) Koga, Y. "Topics on and around post-harvesting stage of rice: Is small rice mill wasteful?" Agricultural Mechanization in Asia, Vol. 7, No. 2, Spring 1976, pp. 38-40.

Contains a general discussion of post-harvest problems in Southeast Asian countries, with losses noted in the 20-50-percent range. Evaluates small rice mills for wastefulness, but gives no specific data. (No refs.)

(B37) Krishnamurthy, K. "Post harvest losses in foodgrains," Bulletin of Grain Technology, Vol. 13, No. 1, Apr. 1974, pp. 33-49.

Reviews loss assessments of various stages of handling several food grains in India. Gives formulas for finding the percentage of weight loss, percentage of damaged kernels, and percentage of moisture loss in a section on the parameters for estimating and defining losses. Presents data giving percentage loss figures for specific times, storage, conditions and causes. (Refs.)

(B38) _____. "Post harvest losses in foodgrains," Bulletin of Grain Technology, Vol. 10, No. 4, Dec. 1972, pp. 291-96.

Briefly identifies problems, such as loss, in wheat storage, transport, and processing. Loss data include the estimated volume of wheat lost daily in the threshing yard to birds and rodents and the total percentage of wheat lost in India. Discusses several causes of grain loss relative to the phase of storage or processing. (No refs.)

(B39) _____. "Storage of food grains: Different structures and economics," New Agricultural Technology and Communication Strategy (ed. S. Dasgupta and M. G. Bhagat). Bombay: National Institute of Bank Management, 1976.

Discusses Indian losses of stored grain and describes proper methods of constructing storage facilities. Reports the percentage of total produce lost in storage from various causes and supports the continuation of research on the costs and benefits of scientific grain storage. (No refs.)

(B40) Lee, C. H., and C. J. Chung. "Grain losses incurred during different post-harvest rice systems," Nongfop Kyfongje yfon. gu., Vol. 3, No. 2, Dec. 1978, pp. 69-87.

Describes an experiment testing the effect of five handling and threshing systems on two varieties of rice in Korea to find the causes and extent of post-harvest losses and the possible methods to reduce such losses. Losses occur at several points during the rice handling and threshing phases. Results show the percentage of total rice lost and the weight of grain of each variety lost in each area of the system. (Refs.)

(B41) Mphuru, A. N. "Losses which occur during harvesting and storage of grains: A Bibliography." Special Report No. 4. Kansas State University, Food and Feed Grain Institute, July 1976, 73 pp.

Points out the need for and controversies over appropriate loss assessments. The bibliography is organized into four areas: detection and microanalysis; estimates of losses due to insects, rodents, and birds; harvesting, handling, conditioning, and processing losses; nutrient losses, fungal damage, and losses in germination. Contains 705 entries, few of which are annotated.

(B42) _____, and M. A. Maro. "Grain storage and handling in the Morogoro and Iriga regions of Tanzania," Tropical Stored Products Information, No. 30, 1975, pp. 35-40.

Examines the extent and causes of grain crop losses. Includes detailed, illustrated examples of storage facilities and practices. Concludes that storage losses could be reduced by modification of storage structures rather than by insecticides, which have proven ineffective. Provides data on the extent of storage losses in African countries, such as the percentage of grain crop lost to insects, the monetary value of crops lost to weevils in Kenya, and the tonnage of locally produced grains lost in Tanzania. (Refs.)

(B43) Peterson, W. H. "In storage drying with supplemental heat." Extension Service Fact Sheet, No. 531. South Dakota State University, Extension Building, Brookings, SD. 5 pp.

Discusses practical information on storing corn with dry heat. Provides conversion tables for finding the percentage of shrinkage loss from the percentage change in moisture content. (No refs.)

(B44) Phillips, R., H. B. Pfost, D. Chung, and J. R. Pedersen. "Review of economic and engineering study: Rice storage, handling, and marketing in the Republic of Indonesia." Report No. 35. Kansas State University, Food and Feed Grain Institute, Mar. 1973, 35 pp.

Reviews the content and adequacy of a report on rice storage, handling, and marketing in Indonesia. Includes estimates of losses at various points in the marketing system, but questions the accuracy of these figures. Provides economic analysis of alternative rice storage and processing facilities, benefit/cost ratios of the amount of grain saved in 13 rice storage facilities, and the minimum rupee returns needed to make the storage facility feasible. (No refs.)

(B45) Pingale, S. V. "Prevention of losses in storage," Bulletin of Grain Technology, Vol. 8, No. 1/2, March/June 1970, pp. 3-13.

Discusses loss methodologies, various kinds of storage facilities, causes and prevention of losses, and predictions for future loss reductions. Presents only limited results on the percentage of crop loss, on the percentage of loss reduction due to treatment, and on costs expressed in rupees per ton per month of scientific storage. (Refs.)

(B46) _____. "Storage losses prevention," The Green Revolution, Vol. 1972, 1972, pp. 127-34.

Discusses the adequacy of loss assessment methodology in evaluating food quality losses, types of farm and commercial storage practices and structures, types of loss prevention methods, and problems in Indian grain storage practices. Data include the rupee cost of various storage facilities and of fumigant processes. (Refs.)

(B47) Prasad, K. "Transportation of foodgrains in India," Bulletin of Grain Technology, Vol. 17, No. 1, Apr. 1979, pp. 60-80.

Broadly discusses Indian grain transportation, giving data on the amounts (tons) of grains handled by different transport forms. Provides a section on transportation losses featuring the lost tonnage and the percentage of total grain transported annually in various regions from 1975 to 1978. Estimates transit loss at 19 rupees per ton as part of the overall cost of transit. (Refs.)

(B48) Rai, L., and S. N. Singh. "Source of infestation and extent of loss in wheat by storage insect pests in Eastern Uttar Pradesh," Bulletin of Grain Technology, Vol. 77, No. 1, Apr. 1979, pp. 14-21.

Surveys grain storage problems in India (1976-77). Focuses on infestation of stored grain in different types of storage facilities and different locations. Reports damage as average number of adult, larva, and pupa per kilogram of grain. Presents results as average weight losses for grains over three time periods: 3, 6, and 9 months of storage. (Refs.)

(B49) Rohrer, R., and C. Geiser. "Kansas State University post-harvest documentation service," Quarterly Bulletin of the International Association of Agricultural Librarians and Documentalists, Vol. 25, No. 1, Winter/Spring 1980, pp. 1-5.

Describes an information system supporting a Food and Feed Grain Institute project that provides worldwide technical assistance and training on post-harvest grain systems. Both the Institute's documents and Postharvest Food Losses in Developing Countries, a 2,000 entry bibliography by the National Academy of Science in Washington, DC, provide the nucleus of the data base. (Refs.)

(B50) Samajpati, J. N., M. S. A. Sheikh, and M. S. Rahman. "Paddy post-harvest technology in Bangladesh," Agricultural Mechanization in Asia, Africa and Latin America, Vol. 12, No. 1, Winter 1981, pp. 39-43, 65.

Describes techniques used in Bangladesh for threshing, parboiling, drying, and storing rice. Discusses the general causes of losses and estimates the percentage of the national rice crop lost in storage. Presents the percentage of weight losses of rice in some Asian countries. (Refs.)

(B51) Shejbal, J. (ed.). Controlled Atmosphere Storage of Grains: An International Symposium Held from 1 to 15 May 1980 at Castelgandolfo (Rome). Amsterdam: Elsevier Scientific Publishing Co., 1980, 608 pp.

Contains 41 international papers on grain storage and the record of the symposium wrapup session. Groups these papers into the following categories: natural airtight storage, entomology of controlled-atmosphere storage, microbiology of controlled-atmosphere storage, artificial controlled-atmosphere storage, preservation of quality in controlled atmospheres, and facilities for artificial controlled-atmosphere storage and economic aspects. Where study results are included, shows figures illustrating percentage of weight losses and operating costs of alternative storage options. (Refs.)

(B52) Singh, D., and R. K. Khosla. "Post-harvest foodgrain losses in India: A review," Agricultural Situation in India. India, Directorate of Economics and Statistics, Vol. 33, No. 8, Nov. 1978, pp. 499-500.

Reviews available estimates of storage losses in Indian food grains. Results include the percentage of food value lost in various post-harvest stages for eight food grains over a 3-year period; the percentage of losses during transportation; the percentage of stored grains lost annually (1963-69); the

percentage of weight loss; the percentage of kernel damage; the percentage of the area's (Uttar Pradesh) crops lost; the tons lost annually in drying, transportation, storage, and distribution; the percentage of transit and storage losses in the purchase and sale value of grains (in rupees); the average wheat losses due to insects; the losses in rice at different post-harvest stages; and the percentage lost in commercial storage. (Refs.)

(B53) Singh, G., and G. S. Mann. "An economic analysis of wheat storage problems in selected markets of Punjab," Agriculture and Agro-Industries Journal, Vol. 4, No. 7/8, July/Aug. 1971, pp. 9-14.

Discusses data on the amount of Indian wheat produced and sold, the amount (in quintals) of wheat purchased by various buyers, the amount arriving at given markets, the private or contracted storage capacity per buyer, and the storage costs (in rupees) of different facilities. Concludes that owning storage facilities is more economical than contracting for them and that more onfarm scientific storage should be used. (No refs.)

(B54) Singh, H., and B. S. Chahal. "A package of practices for efficient storage of food grains," Indian Farming, Vol. 20, No. 3, Aug. 1970, pp. 39-40, 43.

Focuses on practical rural activities to reduce common food-grain storage losses such as inspection, pesticides, preservatives, fumigants, and rat proofing. Estimates that 10 percent of food grains are lost annually in post-harvest handling in India. (No refs.)

(B55) Sprouse, W. T., and L. W. Smith. "On-farm storage: A marketing alternative." Athens Bulletin No. 846. Georgia Cooperative Extension Service, College of Agriculture, May 1981, 10 pp.

Uses data from a Georgia grain production survey (1976-80) to illustrate the economic advantages of onfarm storage. Identifies moisture loss and shrinkage as additional variable costs of onfarm storage and evaluates these costs for soybeans and corn stored over 9 months. (Refs.)

(B56) Srivastava, P. K., B. P. Tripathi, G. K. Girish, and K. Krishnamurthy. "Studies on the assessment of losses; Part III: Conventional grain storage practices and losses in rural areas in Western Uttar Pradesh," Bulletin of Grain Technology, Vol. 11, No. 2, June 1973, pp. 129-39.

Discusses village wheat and maize storage practices. Reports the percentage of farm-stored grain damaged in different storage structures, the change in grain moisture content over 6 months storage in different structures, the variation in kernel damage over 6 months storage in different structures, and the percentage of loss in maize stored for 3 months in different structures. (Refs.)

(B57) Stokes, S. P. D. (ed.). "Proceedings of a seminar on post-harvest grain losses: Introducing food loss assessment studies into loss reduction programmes," Tropical Stored Products Information. Special Issue No. 36. London: Tropical Products Institute, Mar. 13-17, 1978, 72 pp.

Reports post-harvest grain losses from several perspectives: loss assessment and loss reduction, case studies on assessment and loss reduction, national priorities for assessment and loss reduction, resource requirements, and future collaboration. Gives results or loss figures mostly as percentages of

national crop(s) lost, the percentage of dry weight lost, and the value of national loss reduction programs. The figures given are generally noted as estimates. (Refs.)

(B58) Tyag, A. K., and G. K. Girish. "Part VII: Studies on the assessment of storage losses of foodgrains by insects--(1) Quantitative assessment," Bulletin of Grain Technology, Vol. 13, No. 2, Aug. 1975, pp. 84-102.

Contains estimates on the extent and conditions of losses in food-grain stores by insects around the world. Discusses the problem of defining loss and presents some figures on the percentage of weight loss for stored grains. (Refs.)

(B59) Wheatley, P. E. "The maize storage problem in the less developed countries of Africa," Chemistry and Industry, No. 22, Nov. 17, 1973, pp. 1049-52.

Discusses onfarm losses due to molds and to rodent and insect pests in maize and grains. Low-cost storage improvements are deemed appropriate for various African climates. Author occasionally presents data on the effectiveness of various techniques in reducing loss (usually the percentage of moisture loss) and estimates the percentage of weight loss for onfarm stored maize in several African countries. (No refs.)

(B60) Woolcock, R. F., and A. Amos. "A cost analysis of an experimental underground wheat silo and its possible application for temporary storage," Quarterly Review of Agricultural Economics, Vol. 30, No. 1, Jan. 1977, pp. 61-71.

Examines the overall cost effectiveness of an alternative temporary grain storage facility. Gives test results showing savings from the experimental storage unit, including the amount and dollar value of lost grain. Includes comments comparing the quality of grain stored in standard units to that stored in the experimental unit. (No refs.)

C. Rapeseed and Spices

(C1) Good, E. A. M., L. M. Stables, and D. R. Wilkin. "The control of mites in stored oilseed rape," British Crop Protection Conference--Pests and Diseases, Vol. 1, 1977, pp. 161-68.

Presents reports on controlling post-harvest losses due to mite infestation in the United Kingdom. Cites information about oilseed rape acreage in the United Kingdom and studies in Canada and France estimating the percentage of stores containing mites. Discusses lab and field trials on pesticide effectiveness and residue levels. (Refs.)

(C2) Mills, J. T., R. N. Sinha, and H. A. H. Wallace. "Assessment of quality criteria of stored rapeseed: A multivariate study," Journal of Stored Product Research, Vol. 14, No. 2/3, June 1978, pp. 121-33.

Evaluates the reliability of the quality criteria used by the grain trade to assess rapeseed and identifies two reliable alternative quality tests. Presents study results that identify seed quality characteristics and estimate frequency of seed diseases. Presents several statistical correlations on quality variables. (Refs.)

(C3) Singh, H. V., D. S. Gupta, T. P. Yadava, and K. D. Hawan. "Post-harvest losses caused by painted bug to mustard," Haryana Agricultural University Journal of Research, Vol. 10, No. 3, Sept. 1980, pp. 407-09.

Reports on the post-harvest losses in Indian mustard crops due to the painted bug. Study results include the weight of seeds lost and the content of nutrient loss in two varieties of mustard. (Refs.)

D. Sugar

(D1) Egan, B. T. "Post-harvest deterioration losses in sugar cane in Queensland," 13th International Society of Sugar Cane Technologists Congress Proceedings, 1969, pp. 1729-35.

Discusses storage losses in sugarcane due to mechanical harvesting. Compares quality levels such as pH, commercial sugar content, and gum content of whole stalk cane to chopped cane. (Refs.)

(D2) Wu, M. T., B. Singh, L. E. Olson, and D. K. Salunkhe. "Control of sucrose loss in sugar beets during storage by chemicals and modified atmosphere and certain associated physiological changes," Journal of the American Society of Sugar Beet Technologists, Vol. 16, No. 2, July 1970, pp. 117-27.

Discusses experiments to reduce sucrose loss in stored sugar beets using pre- and post- harvest chemical treatments. Gives the percentage of sugar loss reduction per treatment over four periods in a year. Estimates the 1966-67 loss of sucrose in North America at over $30 million. (Refs.)

E. Specific Vegetables: Miscellaneous

(E1) Angle, T. L., and M. O'Brien. "Damage losses in handling processing tomatoes in bulk," Transactions of the American Society of Agricultural Engineers, Vol.17, No.3, May/June 1974, pp. 564-66.

Estimates juice loss from processing at 3-8 percent of total weight. Discusses both experiments using truck bottom pads to reduce damage and results of field tests on different pads. These results quantify juice loss in inches per load versus pad modules of elasticity. (Refs.)

(E2) Bartz, J. A. "Causes of post harvest losses in a Florida tomato shipment," Plant Diseases, Vol. 64, No. 10, Oct. 1980. pp. 934-37.

Analyzes a decayed tomato shipment by breaking decay into the percentage of lesions caused by various problems such as wounds, decay bacterias, and other pathogens. (Refs.)

(E3) Blatchford, S. M. and A. J. Wye. "Crop storage bibliography (with particular reference to the storage of durable agricultural produce in tropical and sub-tropical countries)." Tropical Products Institute Report No. 64. June 1971, 12pp.

Includes 162 references to crop storage issues that are organized by literature type (journals, texts, leaflets, articles, and so forth), including some post-harvest citations. (Refs.)

(E4) Booth, R. H. "Post-harvest deterioration of tropical root crops: Losses and their control," Tropical Science, Vol. 16, No. 2, 1974, pp. 49-63.

Discusses post-harvest losses of tropical root crops (cassavas, yams, sweetpotatoes, solanum potatoes, and aroids) in relation to causes such as physical factors, extreme temperatures, and physiological factors. Quantifies losses in terms of percentage of weight loss with respect to total national crop production. Results include the periods (weeks) of extended storage life due to treatments, the reduced percentage of crops rejected for exporting, and a comparison of weight loss during storage before and after curing. (Refs.)

(E5) Brown, A. C., R. W. Kear, and J. P. Symons. "Fungicidal control of Botrytis on cold-stored white cabbage," Proceedings of the 8th British Insecticide and Fungicide Conference, Vol. 1, 1975, p. 339-46.

Examines treatments to control storage rot in white cabbage. The authors provide weight loss, percentage of rot, and percentage of increased marketability results showing that fungicidal dusting treatments can improve overall marketability of cabbage crops. (Refs.)

(E6) Commonwealth Bureau of Horticulture and Plantation Crops. Annotated Bibliography on Storage of Onions, 1968-71, Query File. No. 6033s. East Malling, England, Jan. 1973, 3 pp.

References 30 citations on onion storage topics, particularly the use of gamma-irradiation to extend storage life. Most of the annotations indicate quantitative loss data in the literature, but none indicates the presence of economic evaluations. (Refs.)

(E7) Coursey, D. G., and R. H. Booth. "Post-harvest problems of non-grain staples," Acta Horticulturae, Vol. 53, Apr. 1977, pp. 23-33.

Discusses common loss problems in non-dry stored crops such as fruits, vegetative stems, yams, potatoes, sweetpotatoes, cocoyams, and cassava. Includes an estimate of the total crops lost (percentage) in storage. (Refs.)

(E8) _____, and F. J. Proctor. "Towards the quantification of post-harvest loss in horticultural produce," Acta Horticulturae, Vol. 49, July 1975, pp. 55-66.

Focuses on losses in tropical horticultural crops (roots, vegetables, and fruit). Summarizes the available data, specifically detailing the percentage of total crop loss for cassavas, yams, sweetpotatoes, and bananas. Discusses losses due to social and technical factors, including the percentage of crop loss and percentage of loss reduction in various countries for citrus and potatoes. (Refs.)

(E9) De Lima, C. P. F. "Appropriate techniques for use in the assessment of country loss in stored produce in the tropics," Tropical Stored Products Information, No. 38, 1979, pp. 15-19.

Describes an approach to assess the losses of stored products in a country that allows the investigator to set the priorities as to the commidity to be studied and the area(s) where the study should take place. (Refs.)

(E10) Furry, R. B. "Continuing research on post harvest storage of cabbage." New York Farm Election Council Progress Report No. 30. May 31, 1973, pp. 16-25.

Compares the effectiveness of two types of long-term controlled-atmosphere storage for New York cabbage. Results include the comparative percentage of weight losses due to trimming, water losses for several storage methods, and the dollar value of cabbage production in selected U.S. areas. (Refs.)

(E11) Garg, J. S., G. N. Singh, and B. B. Singh. "Potato--more profit from better storage and marketing," Indian Farming, Vol. 23, No. 6, Sept. 1973, pp. 17-18.

Compares the cultivation costs per hectare of potato quintals, the producers' share of consumer price and marketing price of potatoes, and the costs of storage per quintal of potatoes across progressive and nonprogressive farms in a given area of India. Gives costs in rupees per quintal for some storage losses due to drying, shrinkage, rot, and so forth. (No refs.)

(E12) Greig, I. "How to cut crop losses; Part 2: Potatoes," Power Farming, Vol. 56, No. 3, Mar. 1977, pp. 2-25.

Discusses losses in the harvesting and storage phases of potato production. Evaluates appropriate methods for reducing disease loss, water loss, and sugar content loss. Gives data on the pound value of losses in potatoes, barley, and sugar beets in the United Kingdom. (Refs.)

(E13) Hansen, H. "Methods of postharvest treatment of potatoes, fruits and vegetables (including tropical fruits): Possibilities and applicability," Landwirtshaftliche Forschug, Sonderheft, Vol. 34, No. 1, 1978, pp. 115-22.

Discusses the need for post-harvest treatments to reduce losses, focusing on appropriate practices and dangers to human health of using new chemicals before they have been fully tested. (Refs.)

(E14) Hinsch, R. T., and R. E. Rij. "Mechanical damage and losses to Crisphead lettuce during marketing," Advances in Agricultural Technology , USDA Science and Education Administration Western Region, Apr. 1980, 9 pp.

Studies packaging and transportation losses in California lettuce. Data include the percentage of a sample damaged at three severity levels for different packaging and loading methods and the percentage of lettuce damaged on arrival at markets. (No refs.)

(E15) Kear, R. W. "The effect of idrodione on the fungal deterioration of stored white cabbage," British Crop Protection Conference--Pests and Diseases, Vol. 1, 1977, pp. 189-95.

Studies storage losses in the British white cabbage crop and finds a 9- to 19-percent increase in production after treatment. Reports the percentage of loss from fungal spoilage, percentage of total losses in marketable products, percentage of infected heads, and percentage of weight losses for various treatments. (Refs.)

(E16) Moline, H. E., and P. D. Millner. "Identification of Mucor mucedo as a postharvest pathogen of fresh market tomato," Phytopathology, Vol. 71, No. 8, Aug. 1981, p. 895 (abstract only).

Describes an experiment identifying the characteristics and decay effect of a new species of stored tomato pathogen. The transportation loss attributed to this species in one tomato shipment is 60- to 80-percent decay. (No refs.)

(E17) Ogata, K. "Improved storage of fruits and vegetables by ionizing radiation," JARQ Japan Agricultural Research Quarterly, Vol. 7, No. 1, Jan. 1973, pp. 55-60.

Studies the effectiveness of irradiation on stored fruits, potatoes, and onions. Reports results on the percentage of sprouting, brown spotting, molding, and ripening that occurs after different levels of radiation treatment. (Refs.)

(E18) Rickard, J. E., O. J. Burden, and D. G. Coursey. "Studies on the isolation of tropical horticultural product," Acta Horticulturae, Vol. 84, Oct. 1978, pp. 115-22.

Indicates that produce stored in the sun develops and retains internal temperatures higher than ambient levels and that these temperatures affect the metabolic processes affecting product quality. Gives results on the grams of mean weight lost in a given crop (carrots, potatoes, and aubergines) at various temperatures. Summarizes other studies on solar radiation impact. (Refs.)

(E19) _____, and D. G. Coursey. "The value of shading perishable produce after harvest," Appropriate Technology, Vol. 6, No. 2, Aug. 1979, pp. 18-19.

Focuses on tropical crops, discussing damage due to incorrect storage techniques. Suggests simple steps that farmers and marketers can employ to reduce losses. Cites studies estimating the percentage of yam crop lost because of unshaded storage. (Refs.)

(E20) Sparks, W. C. "Influence of ventilation and humidity during storage on weight and quality changes of Russet Burbank potatoes," Potato Research, Vol. 16, 1973, pp. 213-23.

Examines the effects of different potato storage techniques. Gives results showing the percentage of weight loss during storage with different ventilation and humidity conditions. Quantifies quality losses as percentages of rot, shrink, flattening, and sprouting. Evaluates processed products for these percentage quality changes. (No refs.)

(E21) _____. "Modern storage methods reduce losses," American Vegetable Grower, Vol. 18, No. 10, Oct. 1970, pp. 32-35.

Generally discusses 20th century developments in potato storage and problems such as weight loss in long-term storage. Focuses on a method to humidify storage areas to reduce weight loss and increase storage life. Results include the percentage reduction of total crop storage losses. (Refs.)

(E22) _____. "Potato bruising can cost you $$$," American Vegetable Grower, Vol. 25, No. 1, Jan. 1977, pp. 14, 16.

Discusses potato bruising as a source of economic losses and various methods to reduce such losses. Reports the percentage of total losses due to bruising, including monetary values of losses due to grade lowering in the United States. Includes a table of injury type and the percentage of weight loss or rot loss correlated with each type. (Refs.)

(E23) _____. "Storage losses of irradiated vs. CIPC treated Russet Burbank Potatoes." Idaho University College of Agriculture Bulletin No. 520, Oct. 1970, 4 pp.

Compares the sprouting reduction from treating potatoes with ionizing irradiation and with chemicals. Presents the percentage of a treatment group receiving acceptable potato grades during various phases of post-harvest handling; concludes that chemical treatment is as effective in stopping sprouting as irradiation and that it reduces wastage. (No refs.)

(E24) _____, and L. V. Summers. "Potato weight losses, quality changes and cost relationships during storage." Idaho University College of Agriculture Bulletin No. 535, Jan. 1974, 14 pp.

Describes a study on potato storability. Includes changes in the potato utilization rate for processing french fries and the percentage of weight loss after storage periods. Gives the dollar costs of weight losses due to different storage practices and the costs of quality changes leading to grade lowering. Examines changes in operating costs to increase storability and the offsetting price increases needed to pay for improved storability. (Refs.)

(E25) Theophiulus, T. W. D. "A statistical review of harvesting and storage losses in cereals and pulses, sugar beets, potatoes, vining peas and beans," The Agricultural Engineer, Vol. 32, No. 1, Spring 1977, pp. 3-5.

Surveys and discusses some 1975-76 estimates of losses in the harvesting and storage phases of several UK crops. Data include crop acreage, the value of crop outputs in British pounds, the tons or kilograms lost per hectare, the monetary value of such loss reductions, the annual tons of output, the percentage of crops lost due to rottage, and the percentage of losses occurring in different phases of post-harvest operations. The author summarizes total storage losses for all crops at 26.76 million pounds. (No refs.)

F. Fruits and Vegetables: General

(F1) Agriculture Group and Food Group Symposium. "Post-harvest handling of fruit and vegetables," Journal of the Science of Food and Agriculture, Vol. 26, No. 3, Mar. 1975, pp. 375-78.

Summarizes papers presented at symposium on Nov. 19, 1974: (1) in "Handling and Storage of Apples and Pears," B. J. Wilkinson discusses the need to reduce wastage and the ways, such as fungicides and cool storage, to reduce wastage; (2) in "The Post-Harvest Handling of Citrus Fruit," K. Milne provides an example of fungal wastage during the marketing phase in a general description of citrus post-harvest loss problems and prevention; (3) in "Post-Harvest Handling of Salad Vegetables," B. S. Deppe focuses on

handling practices in Spanish tomatoes to describe problems and alternatives in post-harvest handling practices; (4) in "Post-harvest Handling of Vegetables," W. G. Tucker estimates the percentage of weight loss in vegetables due to transpiration, implying that these weight losses can be reduced with appropriate storage practices; also gives percentage level of damage to potatoes and carrots due to mechanical harvesting (refs.); and (5) in "Microbiology of Stored Soft Fruit and Vegetables," C. Dennis relates micro-organisms to storage spoilage, fungi, and bacteria in particular; discusses loss-related properties of plant tissue such as natural or wound openings and properties of the micro-organisms such as toxin production lethal to plant tissue.

(F2) Conway, R. K. "An Economic Perspective of the California Mediterranean Fruit Fly Infestation." NED Staff Report No. AGES 820414. U.S. Dept. of Agr., Econ. Res. Serv., 1983, 15 pp.

Examines the pre- and post-harvest costs of the medfly infestation and subsequent eradication efforts. Estimates the dollar value of medfly damages, including the impact of changes in supply on export and domestic food prices. Estimates that 20 percent of the California fruit and vegetable crop will be removed from the market because of the medfly. (Refs.)

(F3) Derbyshire, D. M. "Post harvest deterioration of vegetables," Chemistry and Industry, No. 22, Nov. 17, 1973, pp. 1051-54.

Discusses deterioration problems in fresh vegetables in East Anglia and methods of reducing such losses. Reports data on storage times and techniques and gives percentage weight loss figures. (Refs.)

(F4) Food and Agriculture Organization of the United Nations. "Food loss prevention in perishable crops." FAO Agricultural Services Bulletin No. 43. Rome, 1981, 72 pp.

Reports on worldwide post-harvest losses in perishable crops (fruits, vegetables, roots, and tubers). Discussion centers on available and developing technologies and programs to reduce losses. Estimates percentage of various crops lost in selected countries and the dollar value of such losses. Addresses the difficulties of loss assessment methodologies, the factors that affect post-harvest losses from handling to socioeconomic factors, and crop-specific problems and treatments. (Refs.)

(F5) Goldberg, O. B. E. "The post-harvest handling of fresh fruits and vegetables." Long Ashton Research Station Report, Long Ashton, England, 1976, pp. 184-99.

Discusses the use of appropriate techniques such as cold storage, precooling, and packing, to store and ship fresh produce, especially citrus and lettuce, to the United Kingdom. Gives details on a variety of practices for loss minimization and handling in each stage of the marketing process from harvest to retail. (Refs.)

(F6) Holsten, G. H. "Handling and storage of horticultural produce in Kenya," Acta Horticulturae, Vol. 49, July 1975, pp. 51-54.

Reports on produce handling, storing, packaging, and transporting practices in Kenya. Illustrates possible improvements with sample cost data. (No refs.)

(F7) Hruschka, H. W. Postharvest Weight Loss and Shrivel in Five Fruits and Five Vegetables. Marketing Research Report No. 1059. U.S. Dept. of Agr., Agr. Mktg. Serv., Feb. 1977, 23 pp.

Describes the percentage of weight loss and percentage of the sample with various degrees of shrivel over various holding times under constant conditions for varieties of apples, nectarines, peaches, pears, persimmons, snap beans, early cabbage, sweet peppers, summer squash, and ripe tomatoes. Notes that weight losses reduce the profitability of produce sold by weight. (Refs.)

(F8) Miles, G. H. Alternative Food Delivery Systems: An Exploratory Assessment. National Science Foundation Grant No. AER 77-07184. Baton Rouge, LA: Experienced Resource Group, Inc., Sept. 1977, 29 pp.

Examines the U.S. fresh fruit and vegetable delivery system. Evaluates future prospects for information that would benefit the system. Identifies waste reduction as a factor in the selection of delivery system alternatives. Estimates the percentage of lost food, the percentage of loss reduction possible, and the net percentage of increase in food supply. (Refs.)

(F9) O'Brien, M., R. B. Fridley, and L. L. Claypool. "Food losses in harvest and handling systems for fruits and vegetables," Transcripts of the American Society of Agricultural Engineers, Vol. 21, No. 2, Mar./Apr. 1978, pp. 386-90.

Examines cling peach, apricot, and tomato losses due to mechanical harvesting, handling, and transportation. Concludes that the magnitude of quality damages and product losses are determined by maturity, storage time, and storage temperature. Gives percentages on the amount of post-harvest losses due to harvesting, sampling and sorting, and transportation damages to peaches and tomatoes, and the percentage of weight loss of these crops due to handling, transport, and maturity. (Refs.)

(F10) Pantastico, E. B. "Postharvest physiology: A practical science." SEARCA Professional Chair Inaugural Lecture, University of Philippines at Los Banos, College, Laguna, May 27, 1977. (Available from College of Agriculture, ASEAN Postharvest Horticulture Training and Research Center, University of the Philippines at Los Banos, College, Laguna). 16 pp.

Describes the Philippine agricultural produce system with regard to harvest activities resulting in losses. Presents data on the percentage of post--harvest handling losses worldwide, the annual nutritional and monetary losses to poor handling in the Philippines, and the dollar value of onion storage losses. Concludes by recommending institutional actions to reducing wastes. (No refs.)

(F11) Richardson, D. G., and M. Meheriuk (eds.). Proceedings of the Third National Controlled Atmosphere Research Conference on Controlled Atmospheres for Storage and Transport of Perishable Agricultural Commodities: July 22-24, 1981, Oregon State University, Corvallis, Oregon. Beaverton, OR: Timber Press, 1982, 390 pp.

Reports the findings of a conference on the benefits of controlled-atmosphere storage of perishable goods. Features papers reporting the physical effects of using controlled atmospheres to extend the storage life of nuts, fruits, and vegetables. Most data are percentages of crop losses occurring in storage. (Refs.)

(F12) Ryall, A. L., and W. J. Lipton. Handling, Transportation and Storage of Fruits and Vegetables; Volume 1: Vegetables and Melons. 2nd. ed. Westport, CN, AVI Publishing Co., Inc., 1979, 588 pp.

Discusses practices of post-harvest handling, storage, and transportation of a range of vegetables and melons. Presents information focusing on the need to practice effective methods to reduce post-harvest losses. Gives figures on the percentage of weight loss and the percentage of damaged goods and specifies treatment practices for specific crops. (Refs.)

(F13) Smith, W. L., Jr., H. E. Moline, and K. S. Johnson. "Studies with Mucor species causing postharvest decay of fresh produce," Phytopathology, Vol. 69, No. 8, Aug. 1979, pp. 865-69.

Reports on a post-harvest fruit pathogen species that attacks stone fruits, strawberries, pears, guavas, and other vegetables and fruits. Results show the pathogen's growth rates in various temperatures and the percentage of fruit infected over time at various temperatures. Suggests low-temperature storage (0° C) to inhibit fungi growth, although this practice would not necessarily stop infection. Peach infections are often caused by unsanitary conditions at packing premises. (Refs.)

(F14) U.S. Department of Agriculture, Human Nutrition Information Service, Consumer Nutrition Division. Conserving the Nutritive Values in Foods. Home and Garden Bulletin No. 90. Apr. 1983 revision, 11 pp.

Discusses nutrient losses in foods occurring during handling, storage, and cooking. Gives the percentage change of vitamin contents during storage and cooking for various fresh fruits, vegetables, meats, and frozen and canned foods. Describes methods to retain higher vitamin content. (No refs.)

(F15) U.S. Department of Agriculture, State Land-Grant Universities, and U.S. Environmental Protection Agency. "The biologic and economic assessment of Maleic Hydrazide, cooperative impact assessment report." Technical Bulletin No. 1634. 1980, 106 pp.

Describes the biological and economic effects of banning the use of the pesticide, Maleic Hydrazide, on tobacco, onions, potatoes, some fruit crops, and various grasses and shrubs. Quantitatively assesses the changes in crop production of each crop resulting from banning this chemical. Estimates the dollar value of onions with different storabilities. Economic results focus on evaluations of cost changes per production unit due to changing the preservative treatments. (Refs.)

(F16) Wright, W. R. "Marketing losses of selected fruits and vegetables at wholesale, retail, and consumer levels in the Chicago area." Marketing Research Report No. 1017. U.S. Dept. of Agr., Agr. Mktg. Serv., Jan. 1975, 21 pp.

Examines losses of six nonlocally grown fruits and vegetables occurring during wholesaling, retailing, and consumption. The results include the percentage of each crop lost in each phase to various causes. (Refs.)

(F17) Wu, M. T., and D. K. Salunke. "Fungistatic effects of sub-atmospheric pressures," Experimentia, Vol. 28, No. 7, July 15, 1972, pp. 866-67.

Concludes that subatmospheric pressure, combined with low temperatures, low relative humidity, and low gas composition can extend the storage life of fruits and vegetables. Gives data on the percentage of mycelial coverage by five fungi under five storage pressure levels. (Refs.)

(F18) Zakopal, J. "The reduction of losses caused by diseases during the storage of fruits and vegetables." Czechoslovak Republik. Ministerstro Studijni informace; Ochrana rostlin, Zemedelstri a lesniho hospodarstvi: Ustav vedeckotechickyeh informaci, Vol. 3, 1973, pp. 55-56.

Describes treatments to reduce specific fruit disorders such as bitter pit or rots. Notes controlled-atmosphere storage as the most effective treatment for vegetables.

G. Apples

(G1) Conway, W. "Effect of post-harvest calcium treatments on decay of stored 'Delicious' apples," Phytopathology, Vol. 71, No. 8, Aug. 1981, p. 868 (abstract only).

Describes an experiment on Maryland and Virginia apples treated with various levels of calcium and then inoculated with Penicillium expansum. Results show the level of decay severity after storage. (No refs.)

(G2) Edney, K. L. "Post-harvest deterioration of fruit," Chemistry and Industry, No. 22, Nov. 17, 1973, pp. 1054-56.

Examines controlling the rotting rate of stored apples by varying the content and temperature of storage atmospheres. Data include the percentage of rotting during storage at differing atmospheric conditions. (Refs.)

(G3) _____, and D. A. Chambers. "Post-harvest treatments for the control of Phytophthora syringae storage rot of apples," Annals of Applied Biology, Vol. 97, No. 2, Mar. 1981, pp. 237-41.

Reports the results of an experiment on apples inoculated by P. syringae. Gives the percentage of rot after different pre- and post-harvest chemical treatments, storage conditions, and time periods. (Refs.)

(G4) Fidler, J. C. "Fruit storage," East Malling Research Station Annual Report, Vol. 1970, Apr. 1971, pp. 65-80.

Describes a range of experiments on post-harvest apple storage treatments. Data cover storage conditions and treatment levels. Includes the percentage of fruits with rots after a simulated marketing period, occasional figures on the percentage of weight loss after treatments, and the percentage of reduced disorders after treatments. (Publications list.)

(G5) Lockhart, C. L., C. A. Eaves, and F. R. Forsyth. "Losses from storage rot of McIntosh apples in Nova Scotia, 1961-1968," Canadian Plant Disease Survey, Vol. 50, No. 2, June 1970, pp. 90-92.

Examines the Nova Scotia McIntosh apple crop for the percentage of total crop lost to rots. Presents the percentage of loss due to rot for Golden Russett and Rome Beauty apples. Reports the percentages of total crop loss per grower due to various rotting pathogens and the average percentage of rot losses per year from those pathogens. Assigns monetary values to rot losses. Discusses the possible effects of rot losses on annual total sales revenues.

(G6) Martin, D., T. L. Lewis, and J. Cerny. "Postharvest treatments of apples for storage disorders, 1967," CSIRO Division of Plant Industry Field Station Record, Vol. 9, No. 1, 1970, pp. 25-36.

Examines controlling scald, breakdown, and pit in stored apples. Data focus on the percentage reduction of each disorder resulting from seven different treatments. (Refs.)

(G7) Sommer, N. F., R. J. Fortlage, R. J. Buchanan, and A. A. Kader. "Effect of oxygen on carbon monoxide suppression of postharvest pathogens of fruits," Plant Disease, Vol. 64, No. 4, Apr. 1981, pp. 347-49.

Examines ability of several atmospheric conditions to affect incidence of fruit disease/decay without reducing fruit quality during storage. Most experiments involve apples rather than citrus. Results include the percentage of fungi lesion or colony extension after different atmospheric storage conditions. (Refs.)

(G8) Upstone, M. E. "Evaluation of chemicals for control of Phytophthora fruit rot in stored apples," British Crop Protection Conference--Pests and Diseases, Vol. 1, 1977, pp. 197-202.

Discusses the effectiveness of pre- and post-harvest fungicide and of soil stabilizer treatments in reducing storage losses. Reports the percentage of samples infected with various treatments. (Refs.)

H. Berries

(H1) Daubeny, H. A., and H. S. Pepin. "Resistance of red raspberry fruit and canes to Botrytis," Journal of the American Society for Horticultural Science, Vol. 106, No. 4, July 1981, pp. 488-90.

Compares the pre- and post-harvest susceptibility of raspberries to Botrytis rots. Data on post-harvest rots indicate the percentage of rot and the firmness rating for 22 clones of raspberries picked over a 2-week period. (Refs.)

(H2) Dennis, C., and R. P. Davis. "The selective effect of fungicides on post-harvest spoilage fungi of strawberries," British Crop Protection Conference--Pests and Diseases, Vol. 1, 1977, pp. 203-10.

Examines various fungicide treatments to strawberries for effect on storage losses. Includes graphs indicating the percentage of spoiled treated berries during a given storage period. Breaks down results by type of disorder. (Refs.)

(H3) Goodwine, W. R., M. J. Ceponis, and R. A. Cappellini. "Effect of CO_2 atmospheres on postharvest decay incidence of blueberry fruits," Phytopathology, Vol. 71, No. 2, Feb. 1981, p. 220 (abstract only).

Discusses an experiment varying the time and atmospheric conditions for stored berry fruits inoculated with various rots. Reports the percentages of rots reduced by appropriate storage conditions. (No refs.)

(H4) Kamoen, O., and G. Jamart. "Improved spray scheme of fungicides on flowering strawberries for Botrytis fruit rot control," Proceedings of the 8th British Insecticide and Fungicide Conference, Vol. 1, 1975, pp. 347-53.

Describes a pre-harvest fungicide treatment to reduce post-harvest Botrytis infections. Focuses on proper fungicide application methods; also shows the amount of pre-treated fruit rotted after a 3-day storage period. (Refs.)

(H5) Schulze, C. P., M. J. Ceponis, and R. A. Cappellini. "The influence of sweating on postharvest decay of blueberries," Phytopathology, Vol. 71, No. 2, Feb. 1981, p. 253 (abstract only).

Discusses the results of using heat treatment to control berry decays. Gives the percentages of decay with and without treatments. (No refs.)

I. Specific Fruits: Miscellaneous

(I1) Akins, R. "Fruit cool stores: The insulated structure," CSIRO Food Preservation Quarterly, Vol. 30, No. 3, Sept. 1970, pp. 51-55.

Discusses the factors affecting the amount of insulation necessary for cool fruit stores in Australia to preserve fruit for off-season markets. Estimates the increase in the number of bushels in Australian cool stores. Discusses the mechanics of building economically viable stores. (Refs.)

(I2) Barkai-Golan, R. "Species of Aspergillus causing post-harvest fruit decay in Israel," Mycopathologia, Vol. 71, No. 1, 1980, pp. 13-16.

Compares the natural incidence of Aspergilli during fruit storage with the incidence on inoculated fruit. Finds various species of Aspergilli have differing pathogenicity levels and identifies the ambient air frequency of each species. Finds one species is highly pathogenic despite fruit inoculation. (Refs.)

(I3) Breinling, J. "Handling and processing experiences with machine harvested fruit," Michigan State Horticultural Society Annual Report, No. 104, 1975, pp. 48-52.

Briefly discusses machine-harvesting apples, pears, and plums and focuses on the variation in losses due to human elements. Presents results on the percentage of decay in stored apples from two different orchards with and without storage treatments. (No refs.)

(I4) Cargill, B. F., C. L. Burton, J. N. Cash, and H. H. Bruns. "Mechanical pitting and post-harvest treatments of Stanley plums," Transactions of the ASAE, Vol. 23, No. 5, Sept./Oct. 1980, pp. 1101-04.

Describes an experiment examining post-harvest treatment and process improvements for Michigan's plum crop, such as hot water treatments. Results include the percentage of the sample with disorders, such as cracking or rot after two different treatments, and the percentage results from taste tests. (Refs.)

(I5) Carter, W. W. "Reevaluation of heated water dip as a postharvest treatment for controlling surface and decay fungi of muskmelon fruits," HortScience, Vol. 16, No. 3, June 1981, pp. 334-35.

Reports experiment results on the effectiveness of hot water and two other chemical treatments in reducing post-harvest disorders in muskmelons. Devises a relative index scale of the differences in fungus growth and the appearance of fruit treated under various conditions. (Refs.)

(I6) Ceponis, M. J., and J. E. Butterfield. "Retail and consumer level losses in western sweet cherries marketed in greater New York," Phytopathology, Vol. 71, No. 2, Feb. 1981, p. 208 (abstract only).

Reports marketing losses of cherries as annual percentages of loss due to various causes. (No refs.)

(I7) Chen, P. M., and W. M. Mellenthin. "Effects of harvest date on ripening capacity and postharvest life on d'Anjou pears ," Journal of American Society for Horticultural Science, Vol. 106, No. 1, Jan. 1981, pp. 38-42.

Contains experimental results showing the changes in pear firmness during storage after different harvesting dates. Discussion focuses on changes in physiological features. (Refs.)

(I8) El-Goorani, M. A., and N. F. Sommer. "Suppression of postharvest plant pathogenic fungi by carbon monoxide," Phytopathology, Vol. 69, No. 8, Aug. 1979, pp. 834-38.

Examines the effects of various CO treatments on the growth rates of various rot-causing organisms. Reports the rate of rot developed per treatment level for orange, lemon, apple, and strawberry pathogens and the relationship of off-flavor to each treatment level. (Refs.)

(I9) Forbus, W. R., Jr., and J. L. Ayres. "Commercial feasibility of an in-line steam process for conditioning pecans to improve shelling efficiency and maintain product quality," Journal of Food Science, Vol. 44, No. 4, July/Aug. 1979, pp. 988-93, 997.

Examines different shell treatments to improve the production of quality nutmeats. Results show the number of shelled nutmeats per plate collected after different shell treatments and the consequent nut color and taste/ quality levels. (Refs.)

(I10) Prasad, S. S., and R. S. Bilgrami. "Investigations on diseases of litchi; Part II: Influence of temperature and humidity on the decay of fruits caused by nine virulent pathogens," Indian Phytopathology, Vol. 26, No. 3, Sept. 1973, pp. 517-22.

Describes an experiment varying storage humidity and temperature to develop nine pathogens of litchi. Gives the percentages of rot loss per original fruit weight. (Refs.)

(I11) _____. "Investigations on diseases of litchi; Part III: Fruit rots and their control by post-harvest treatments," Indian Phytopathology, Vol. 26, No. 3, Sept. 1973, pp. 523-27.

Describes experiments to reduce post-harvest litchi fruit losses with fungicides. Eleven treatments are effective in controlling at least some pathogens. The only quantifications of effectiveness given are increases in storability. (Refs.)

(I12) Rippon, L. E. "Cutting down post-harvest wastage with fungicides," Agricultural Gazette of New South Wales, Vol. 88, No. 6, Dec. 1977, pp. 24-27.

Describes common disorders and recommends specific fungicidal treatments for apples, pears, bananas, citrus, grapes, rock melons, mangoes, strawberries, and stone fruit. (No refs.)

(I13) Smock, R. M. "Controlled atmosphere storage of fruits," Horticultural Reviews, Vol. 1, 1979, pp. 301-36.

Reviews controlled-atmosphere storage articles, including specific studies on apples, pears, small fruits and grapes, stone fruits, and subtropical and tropical fruits (citrus). Discusses reactions to controlled atmosphere in terms of increased storage days or decreased fruit spoilage. (Refs.)

(I14) Sundraraj, J. S., S. Muthuswamy, and A. Palaniswamy. "Spoilage of fruits in storage," Farm and Factory, Vol. 4, No. 2, Dec. 1969, pp. 19-22.

Identifies common diseases and disorders of bananas, mangoes, citrus, and grapes. Suggests appropriate control techniques such as temperature management and chemical treatments to reduce losses. (No refs.)

J. Tropical Fruit Produce

(J1) Akamine, E. K. "Problems in shipping fresh Hawaiian tropical and subtropical fruits," Acta Horticulturae, Vol. 57, Oct. 1976, pp. 151-61.

Discusses problems in the storage and transportation of pineapples, litchis, avocados, mangoes, bananas, and papayas. Includes production levels and outshipment dollar values of pineapples and papayas. (Refs.)

(J2) Alvarez, A. M. "Fruit quality and post-harvest diseases in the mainland markets." Miscellaneous Publication No. 15. University of Hawaii at Manoa, Cooperative Extension Service, Dec. 1977, pp. 19-33.

Examines the market condition of Hawaiian papayas in California markets after surface shipping. Suggests new treatments and packaging to reduce losses. Gives results on the percentage of diseased fruit after shipping by kind of packaging and the percentage of marketable and diseased fruit removed from cold storage and treated by various chemicals. Gives the retail market value of shipment losses due to disease and the percentage of damaged fruit. (Refs.)

(J3) Coursey, D. G., O. J. Burden, and J. E. Rickard. "Recent advances in research on post-harvest handling of tropical and subtropical fruit," Acta Horticulturae, Vol. 57, Oct. 1976, pp. 135-43.

Focuses on the treatments and methods to reduce post-harvest losses. Gives results on the percentage of losses reduced by improved transporta-

tion and appropriate temperature control. Includes extended storage periods for avocados. (Refs.)

(J4) Meredith, D. S. "Recent advances in control of post-harvest deterioration using thiabendazole with special reference to tropical and subtropical crops," British Crop Protection Conference--Pests and Diseases, 1977, Vol. 1, 1977, pp. 179-87.

Reviews the potential use of thiabendazole as a general post-harvest fungicide. Suggests alternating this fungicide with others to avoid developing a resistant strain. Describes treatment procedures such as packinghouse conditions, applications, and concentrations of fungicides. Estimates the percentage of papaya and avocado crop losses to fungi. Gives the percentage of fungus damage reduced by treatments for most crops. (Refs.)

(J5) Pantastico, E. B. (ed.). Postharvest Physiology, Handling and Utilization of Tropical and Subtropical Fruits and Vegetables. Westport, CN: AVI Publishing Co., Inc., 1975, 560 pp.

Discusses factors affecting the physical quality of several fruits and vegetables. Focuses on chemical and physiological changes after harvesting. Describes alternative produce-handling practices and presents the physical effects. Gives the costs of operations, the percentage of weight loss, and the percentage of spoiled or decayed food after various treatments. (Refs.)

(J6) Silvis, H., A. K. Thompson, S. K. Musa, O. M. Smith, and Y. M. Abdulla. "Reduction of wastage during post-harvest handling of bananas in the Sudan," Tropical Agriculture (Guilford), Vol. 53, No. 1, Jan. 1976, pp. 89-94.

Investigates the field dehandling of bananas and treatments to reduce wastage. Presents wastage as 40 percent of the Sudanese banana crop. Gives percentages of weight loss after various treatments and the percentage of fingers with transport bruising by different packagings. (Refs.)

(J7) Sohi, H. S. "Control of post-harvest storage rot of tropical and subtropical fruits," Pesticides, 1976 Annual, pp. 48-53.

Describes fruit disorders and recommends treatments shown to minimize post-harvest losses. Estimates storage losses of 20 percent of the total Indian fruit and vegetable production at $200 million. (Refs.)

(J8) Tandon, R. N., Jamaludin, and M. P. Tandon. "Studies on the control of post-harvest decay of fruits and vegetables," National Academy of Sciences India: Proceedings, Vol. 46, Section B, No. 1/2, 1976, pp. 65-71.

Examines the percentage of rot in different fruits due to different pathogens. Includes results on the percentage of rot in mangoes, papayas, bananas, and limes stored at different temperatures and treated with various fungicides. (Refs.)

(J9) Tirmazi, S. I. H., and R. B. H. Wills. "Retardation of ripening of mangoes by postharvest application of calcium," Tropical Agriculture, Vol. 58, No. 2, Apr. 1981, pp. 137-41.

Examines the effects of treatments on mangoes. Gives various physiological ripening changes occurring during storage after different calcium treatments. Includes results of a taste test on fruit quality after treatment and storage. (Refs.)

(J10) Wilson, L. G. "Handling of postharvest tropical fruit crops," HortScience, Vol. 11, No. 2, Apr. 1976, pp. 119-30.

Describes the banana exportation process (packaging, transportation, and storage). Discusses problems and potentials of increasing the marketability of tropical fruits. (No refs.)

K. Citrus Fruits

(K1) Bancroft, M. N., P. D. Gardner, J. W. Eckert, and J. L. Baritelle. "Comparison of Decay Control Strategies in California Lemon Packinghouses," Plant Disease, Vol. 68, No. 1, Jan. 1984, pp. 24-28.

Describes a two-season field experiment comparing the effectiveness of three different packinghouse sanitation strategies in controlling Penicillium contaminations. Results include various measures of spore populations in packinghouse atmospheres, the percentage of spores found resistant to thiabendazole, and the percentage of decayed lemons during storage or marketing. Identifies the packinghouse sanitation strategy providing the largest economic benefit through reduced numbers of decayed fruit sent to market and specifies the dollar value of that benefit. (Refs.)

(K2) Ben-Yehoshua, S. "Gas exchange, transpiration, and commercial deterioration in storage of orange fruit," Journal of the American Society for Horticultural Science, Vol. 94, No. 5, Sept. 1969, pp 524-28.

Examines the ways that changes in transpiration and respiration rates during storage affect orange fruit's commercial quality as measured by a series of indexes on firmness, salability, "Button," and appearance. Includes results on percentage changes in peel water content and thickness after storage and results on treatments such as plastic coating, temperature, and humidity changes. (Refs.)

(K3) Blunden, G., E. M. Jones, H. C. Passam, and E. Metcalf. "Increases in chlorophyll retention times of limes after post-harvest immersion in N6-benzyladenine and gibberellic acid," Tropical Agriculture, Vol. 56, No. 4, Oct. 1979, pp. 309-19.

Compares the degreening and wilting rates of limes after two different treatments. Shows that waxing is most beneficial in ambient humidity and that gibberellic acid treatments are most effective in slowing degreening. Presents the rate of degreening for each treatment over several storage periods, the percentage of wasted limes, and the average weight loss per fruit for two humidity levels. (Refs.)

(K4) Brown, G. E., and C. R. Barmore. "The effect of ethylene, fruit color, and fungicides on susceptibility of Robinson tangerines to anthracnose," Proceedings of the Florida State Horticultural Society, Vol. 89, May 1, 1977, pp. 198-200.

Examines susceptibility of degreened tangerines to decay after different fungicide treatments. Presents the percentages of four kinds of decays found after storage of fruits treated with various fungicides. (Refs.)

(K5) Camp, T. H., and W. W. Carter. "Evaluation of a refrigerated barge-on-ship system and loading patterns for post-harvest quality of exported Texas grapefruit," Journal of the American Society for Horticultural Science, Vol. 104, No.5, Sept. 1979, pp. 678-81.

Evaluates a prototypical refrigerated barge for improvements in the arrival condition of grapefruit. Indicates no improvements in fruit quality after varying the method of crate stacking, but finds improvements in slowing the aging of fruits and in reducing the percentage of weight loss during the voyage. (Refs.)

(K6) Cheema, S. S. "Decay of citrus fruits in storage and its control," Agriculture and Agro-Industries Journal, Vol. 5, No. 5, May 1972, pp. 14-16.

Summarizes several articles on post-harvest fruit spoilage due to molds. Discusses the extent of losses (percentage of crop lost in India), kinds of pathogens, controlled-atmosphere storage, and chemical treatments. (Refs.)

(K7) Choudhari, K. G., and G. K. Kumbhare. "Post harvest life of sweet orange (Citrus sinesis L. Osbeck) as influenced by various polythene film packs," Journal of Maharastra Agricultural Universities, Vol. 4, No. 2, May 1979, pp. 228-29.

Examines the effect of different types of plastic wrappings on sweet orange storability. Includes results on the percentage of weight loss and percentage of rot for various gauges and ventings of wrappings after storage. (Refs.)

(K8) Davenport, T. L., and C. W. Campbell. "Stylar-end breakdown: A pulp disorder in 'Tahiti' lime," HortScience, Vol. 12, No. 3, June 1977, pp. 246-48.

Estimates that 40 percent of packinghouse losses in south Florida result from stylar-end breakdown. Describes common disorder symptoms, timing, and causes. This disorder is a pulp problem catalyzed by a traumatic event during harvesting or handling. (Refs.)

(K9) Eckert, J. W. "Post-harvest citrus diseases cost industry millions yearly," Avocado Grower, Vol. 4, No. 6, June 1980, pp. 36-47.

Discusses citrus diseases, conditions under which they occur (such as fruit-to-fruit contact or high temperature storage), treatments to control wastage (such as careful handling and storage), and application of fungicides. (No refs.)

(K10) _____. "Post-harvest diseases of citrus fruits," Outlook on Agriculture, Vol. 9, No. 5, 1978, pp. 225-32.

Notes that loss data based on decay are not enough information on which to base an economic evaluation. Estimates that 25 to 50 percent of non-treated citrus decays. Describes the major disease affecting citrus and the related treatments for citrus loss reduction. (Refs.)

(K11) _____, and M. J. Kolbezen. "Influence of formulations and application method on the effectiveness of benizimidazole fungicides for controlling post-harvest diseases of citrus fruits," Netherlands Journal of Plant Pathology, No. 83, Supplement I, 1977, pp. 343-52.

Investigates fungicide application methods for controlling post-harvest fungi on citrus. Quantifies fungi reduction for several fungicides by a Penicillium sporulation index. (Refs.)

(K12) Farooqi, W. A., M. Ahmed, and Z. M. Khalid. "Post-harvest research on citrus fruits at the Nuclear Institute for Agriculture and Biology, Pakistan," Citrus Industry, Vol. 60, No. 2, Feb. 1979, pp. 45-49.

Examines the reduction in crop losses from gamma radiation treatments, various fungicides, and packaging variations for oranges, mandarins, grapefruits, lemons, and limes. Estimates a 10- to 15-percent crop loss for citrus and gives a rupee value for this loss. (Refs.)

(K13) Hall, D. J. "Packinghouse strategies for the control of fungicide resistant molds," Proceedings of the Florida State Horticultural Society, Vol. 90, 1977, pp. 138-41.

Reports on packinghouse handling of lemons. Investigates the flow of Penicillium spores among the rooms in which fruit might contract the disorder. Makes recommendations to improve the design of packinghouses and for activities that existing packinghouses can take to minimize losses. (Refs.)

(K14) Hall, E. G. "Precooling and container shipping of citrus fruits," CSIRO Food Research Quarterly, Vol. 32, No. 1, Mar. 1972, pp. 1-10.

Discusses methods of precooling and their effect on fruit weight losses. Discusses the storage cooling rate for various packaging and storage conditions. Gives comparative cooling speeds for apple bushels in hours and in percentage of weight loss of stored oranges relative to their position in the storage bin. Discusses the effect of temperature and packaging during transport. (Refs.)

(K15) Harding, P. R., Jr. "R23979, a new imidazole derivative effective against post harvest decay of citrus by molds resistant to thiabendazole, benomyl and 2-aminobutane," Plant Disease Reporter, U.S. Agricultural Research Service Crops Division, Vol. 60, No. 8, Aug. 1976, pp. 643-46.

Compares the effectiveness of different fungicides in reducing the percentage of decayed fruit found in each sample. Includes results on the percentage of decayed fruits after different fungicide treatments. (Refs.)

(K16) Kaplan, H. J., and B. A. Dave. "The current status of imazalil: A Postharvest fungicide for citrus," Proceedings of the Florida State Horticultural Society, Vol. 92, June 1, 1980, pp. 37-43.

Summarizes the effectiveness of imazalil against many common fungi. Gives results on the percentage of decay controlled, the percentage of sporulation controlled, the residue left, and the development of resistant strains. Provides an update on the legal status of fungicide use. Includes results on the number of soiled and decayed fruit per box. Cites reported estimates

of annual losses in shipping and retailing fruits and vegetables at over $200 million. (Refs.)

(K17) Klotz, L. J., and P. R. Harding. "Control of post harvest decay of citrus fruits," Citrograph, Vol. 55, No. 7, May 1970, pp. 261-62.

Describes common citrus diseases, treatment procedures, including fungicide application, packaging, and storage conditions. (Refs.)

(K18) Kuramoto, T., and S. I. Yamada. "DF-125, a new experimental fungicide for the control of Satsuma Mandarin postharvest decays," Plant Disease Reporter, U.S. Agricultural Research Service, Crops Research Division, Vol. 60, No. 10, Oct. 1976, pp. 809-12.

Examines the relative effectiveness of DF-125 to standard fungicides in various storage and treatment conditions. Gives the percentage of decay from various disorders after different storage periods and treatments. (Refs.)

(K19) Laville, E. "Experiment on fungicidal treatment applied to citrus after harvest: Effect of Imazalil," Fruits, Vol. 33, No. 2, Feb. 1978, pp. 101-05.

Examines the effectiveness of imazalil against benzimidazole-resistant Pencillium mold strains. Gives results on various time, temperature, and treatment levels affecting the percentage of fruit decay. (Refs.)

(K20) McCornack, A. A. "Postharvest weight loss of Florida citrus fruits," Citrus Industry, Vol. 57, No. 7, July 1976, pp. 11-13.

Investigates citrus weight losses under various storage temperature, humidity, and packaging (carbons vs. mesh bags) conditions. Gives the percentage of weight loss during degreening practices. (Refs.)

(K21) _____. "Postharvest weight loss of Florida citrus fruits," Proceedings of the Florida State Horticultural Society, Vol. 88, Mar. 1976, pp. 333-35.

Examines storage weight loss in grapefruit and oranges in different humidity, storage, and temperature conditions. Includes results showing the percentage of weight loss reduction from proper conditions for various storage periods. (Refs.)

(K22) _____, and G. E. Brown. "Benlate, an experimental post-harvest citrus fungicide," Proceedings of the Florida State Horticultural Society, Vol. 82, 1969, pp. 235-38.

Investigates fruit condition, application methods, and storage time in relation to post-harvest benlate treatments. Gives results on the percentage of decay found in oranges, grapefruit, and tangerines. (Refs.)

(K23) _____. "Benlate, an experimental preharvest fungicide for control of postharvest citrus fruit decay," Proceedings of the Florida State Horticultural Society, Vol. 82, 1969, pp. 39-43.

Investigates grove applications of benlate. Gives results on the percentage of stem-end rot, the percentage of green mold per picking after grove applications, and the percentage of decay after different storage times for

fruit treated with different kinds of benlate. Gives the percentage of D. natalensis infection found in oranges as a function of rainfall in inches per month. (Refs.)

(K24) _____. "Decay control of Florida citrus fruits with imazalil," Proceedings of the Florida State Horticultural Society, Vol. 90, 1977, pp. 141-44.

Compares imazalil and benlate post-harvest fungicides to illustrate imazalil's effectiveness against benomyl-resistant strains of green and blue molds. Results include the percentage of decay inhibited by each treatment on eight strains of fruit pathogens, the average percentage of decay in treated oranges and tangerines, and the percentage of decay over differing storage periods for imazalil- and benlate-treated fruits. (Refs.)

(K25) _____, and J. J. Smoot. "R23979, an experimental postharvest citrus fungicide with activity against benzimidazole-resistant penicilliums," Plant Disease Reporter, U.S. Agricultural Research Service, Crops Research Division, Vol. 61, No. 9, Sept. 1977, pp. 788-91.

Investigates the effectiveness of a new fungicide for reducing rot in oranges. Gives results on the percentage of inhibition of eight rot-causing organisms and the percentage of decay after treatment with various fungicides. (Refs.)

(K26) McGlasson, W. B., and I. L. Eaks. "A role for ethylene in the development of wastage and off-flavors in stored 'Valencia' oranges," HortScience, Vol. 7, No. 1, Feb. 1972, pp. 80-81.

Investigates decay in oranges under differing controlled atmosphere conditions. Finds ethylene is present in cases of greater percentages of decay over different storage periods. (Refs.)

(K27) Pelser, P. du T. "Twist picking can reduce post-harvest losses in Valencias caused by brown stem-end rot," The Citrus and Sub-Tropical Fruit Journal, No. 475, July 1973, pp. 5-6.

Investigates the extent of injury and post-harvest greenmold decay for two orange-picking methods. Pulling appears to be superior to clipping. Gives results on the percentage of total post-harvest decay and stem-end rot in oranges picked by each method. (Refs.)

(K28) Prasad, K. "Fungitoxicity of acetaldehyde vapour to some major post-harvest pathogens of citrus and subtropical fruits," Annals of Applied Biology, Vol. 81, No. 1, Sept. 1975, pp. 79-81.

Examines fumigation methods to reduce the presence of fruit pathogens. Determines the proper concentration of the fumigant by finding the level of pathogens destroyed at each concentration level. (Refs.)

(K29) Ram, B., and R. Naidu. "Fungicidal control of post-harvest decay of citrus fruits," Pesticides, Vol. 10, No. 9, Sept. 1976, pp. 32, 39.

Examines the effectiveness of a few fungicides in minimizing citrus post-harvest decay in India. Gives the percentage of incidence of common storage rots after treatment with various fungicides over a constant storage period. (Refs.)

(K30) Rippon, L. E. "Comparison of four systemic fungicides for post-harvest treatment of citrus," Australian Journal of Experimental Agriculture and Animal Husbandry, Vol. 13, No. 65, Dec. 1973, pp. 724-26.

Compares the relative effectiveness of thiabendazole, benomyl, thiophanate-methyl, and methyl ester of benzimidazol-2-ylcarbamic acid to control Penicillium digitalium in Washington navel oranges. Gives results on the percentage of the sample lost after storage under each treatment. (Refs.)

(K31) _____. "Sec-butylamine for citrus postharvest mold control," Agricultural Gazette of New South Wales, Vol. 89, No. 3, June 1978.

Identifies an alternative fungicide for use on benomyl-resistant strains of molds. Gives methods for treating citrus before storage. (No refs.)

(K32) Seberry, J. A., and E. G. Hall. "Controlled atmosphere storage of citrus fruit," Agricultural Gazette of New South Wales, Vol. 81, No. 10, Oct. 1970, pp. 564-67.

Discusses controlled-atmosphere storage of lemons, grapefruit, mandarins, and oranges, Measures benefits as the improvement in loss reductions over uncontrolled-atmosphere storage. Gives the percentage of oxgyen and carbon dioxide held by the fruit after storage and the flavor ratings by a panel of tasters. Grapefruit decay under some conditions became "excessive." Notes mandarin storage life is basically unaffected by controlled-atmosphere storage. (Refs.)

(K33) Singh, J. P., and O. P. Gupta. "Control of postharvest decay in mandarin hybrids and sweet-orange during storage," Indian Journal of Agricultural Science, Vol. 49, No. 11, Nov. 1979, pp. 862-66.

Examines the percentage of decay or of decay reduction affected by packaging and by chemical treatments to Indian citrus varieties during storage. (Refs.)

(K34) Smoot, J. J., and A. A. McCornack. "The use of potassium sorbate for citrus decay control," Proceedings of the Florida State Horticultural Society, Vol. 91, 1978, pp. 119-22.

Investigates the effectiveness of potassium sorbate as a post-harvest fungicide. Gives results on the percentages of six post-harvest diseases inhibited by altering the potassium sorbate concentrations. Describes the decay in four varieties of oranges, tangerines, and grapefruits following no treatment, benomyl treatment, and potassium sorbate treatment. (Refs.)

(K35) _____, and C. F. Melvin. "A comparison of post-harvest fungicides for decay control of Florida oranges," Proceedings of the Florida State Horticultural Society, Vol. 82, 1969, pp. 243-46.

Compares the relative effectiveness of six fungicides against decay in Florida orange varieties. Presents the total percentage of decay and the percentage of decay occurring in shipment after various fungicide applications. (Refs.)

(K36) Sudasivam, R., S. Muthuswamy, and J. S. Sundararaj. "Waxed Sathgudi (sweet orange) fruits can be held longer in storage," Farm and Factory, Vol. 6, No. 2, Dec. 1971, pp. 27-28.

Indicates that waxing oranges increases fruit storage life under room and cool temperatures. Includes results on the percentage of sound fruit after storage and the percentage of weight loss for waxed and unwaxed fruit. (No refs.)

(K37) Wild, B. L., L. E. Rippon, and C. J. Rigney. "Research at the Gosford Horticultural Post-Harvest Laboratory," Agricultural Gazette of New South Wales, Vol. 86, No. 4, Aug. 1975, pp. 24-27.

Suggests that green mold costs the citrus industry more than $3 million a year in wastes and lost markets. Describes treatments for green mold, fruit weight loss, degreening, and lemon and mandarin storage. Also discusses disinfestation research affecting export and trade. (No refs.)

(K38) Wild, B.L., L. E. Rippon, and J. A. Seberry. "Comparison of thiabendazole and benomyl as post-harvest fungicides for wastage control in long term lemon storage," Australian Journal of Experimental Agriculture and Animal Husbandry, Vol. 15, No. 72, Feb. 1975, pp. 108-11.

Compares the long-term effectiveness of two fungicides on the percentages of green mold, stem-rot, and total wastage under ambient and cool storage conditions. (Refs.)

☆ U.S. GOVERNMENT PRINTING OFFICE: 1987—201-089/60070

UNITED STATES DEPARTMENT OF AGRICULTURE
ECONOMIC RESEARCH SERVICE
1301 NEW YORK AVENUE, NW.
WASHINGTON, D. C. 20005-4788